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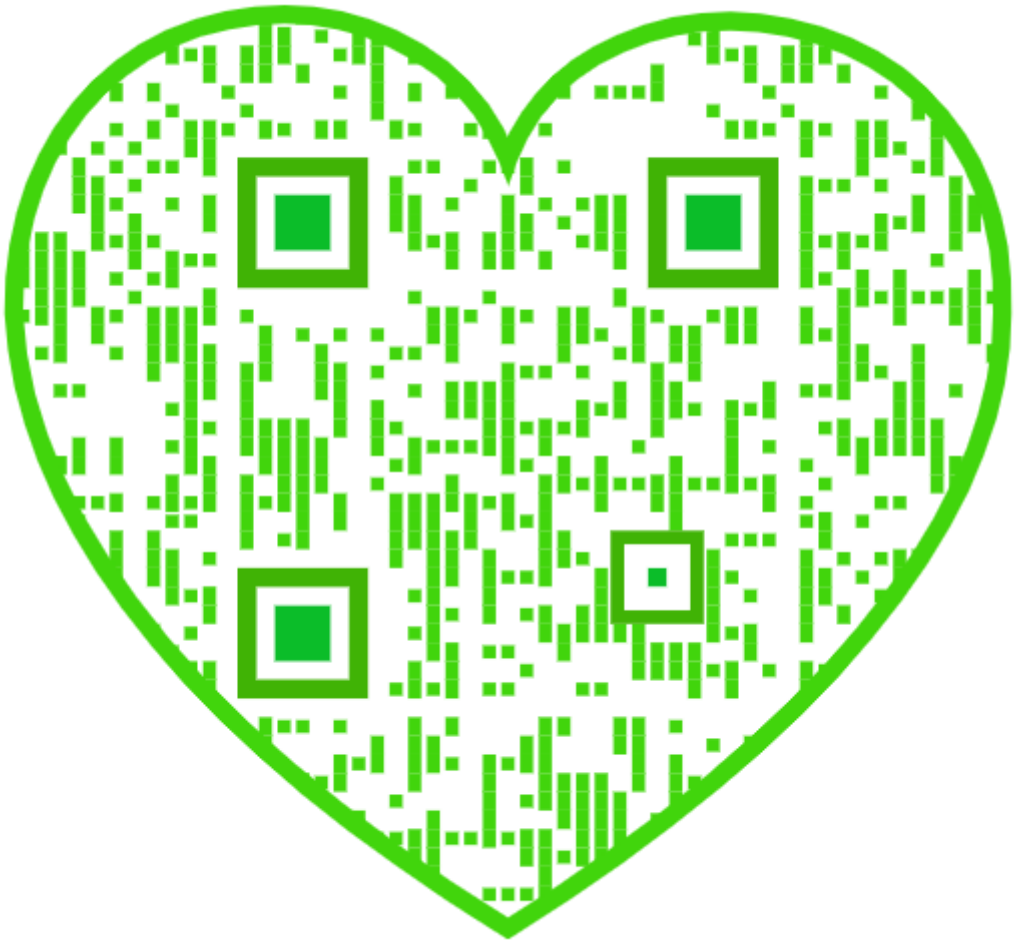
Drafting Room Methods

Standards and Forms

CHARLES D. COLLINS



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DRAFTING ROOM METHODS
STANDARDS AND FORMS

DRAFTING ROOM METHODS

STANDARDS AND FORMS

A REFERENCE BOOK FOR
ENGINEERING OFFICES
AND DRAFTSMEN

BY
CHARLES D. COLLINS
M. AM. SOC. C. E.

ILLUSTRATED

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INTRODUCTION

It has heretofore generally been the custom for each company starting or operating a drafting room, to compile its own set of Standard Practice Sheets at much expense of time and with divers results.

This book is an attempt to describe methods and illustrate forms which would be generally applicable in engineering offices and drafting rooms and combine with this the conventional symbols or standards for the different branches of drafting, such as Architectural, Electrical, Mechanical, Patent Office, Structural, and Topographical.

Provision is also made in the index and at the end of each part for the inclusion of special information, data, instructions, etc., pertaining only to the business of each user, and the addition of which information should be a convenience and a step toward completeness.

Parts I and III are intended for those directing a drafting room, as well as draftsmen. The directions for draftsmen and particularly tracers are necessary if uniformity of work is to be attained; otherwise each man will do his work in his own way and the results will be anything but uniform. Part II will be of most value to draftsmen. Here it has been endeavored to give as complete a list of standard symbols as is now available and which either have no traceable parentage or have come into general use through the actions of Government Departments, Committees of the various Engineering and Manufacturers' Societies, and recommendations of the Engineering Publications. To all of these, grateful acknowledgment

is made for the matter used, as noted on the respective standards. Part IV is intended to give some of the tables most often referred to by the draftsman without entering the field of the engineering handbook.

The book was first compiled for the engineering division of a rapidly growing organization engaged in both construction and manufacture. A copy was given to each engineer, draftsman, and tracer, and the results attained in standardization and in the improved operation of the division encouraged the hope that it would prove as useful in other offices. The copy in the hands of the new man, with instructions and an opportunity given him to become familiar with it, was also found to materially reduce the not inconsiderable expense of instructing and training the new employee.

C. D. C.

New York, *May* 4, 1918

PART I

METHODS

"Method goes far to prevent trouble in business, for it makes the task easy, hinders confusion, saves abundance of time, and instructs those who have business depending what to do and what to hope."

—William Penn.

ARRANGEMENT AND EQUIPMENT

I

THE DRAFTING ROOM

Arrangement. — Many companies give this less consideration than any of their other departments in the matter of location, space per man, ventilation, and light. Why this is so is a mystery to one who knows the expense of running a large drafting room and the difference in output under good and adverse conditions.

The ideal drafting room would be one in a quiet location, with freedom from dust, plenty of north light, ventilation of the best, and at least sixty square feet of floor space per man. Given the proper men, then ventilation and light will be the next two factors affecting output, and any improvement in them will be reflected in the work. If artificial light has to be used, it should be indirect, with walls and ceiling tinted to prevent glare.

Equipment. — Following is a list of the principal articles of equipment of a drafting room, which have been selected only after trial and proven satisfaction.

Drafting Machine. — This tool is now so well known and its utility for detail work so well demonstrated, that its purchase is only a question of the kind and volume of work to be done.

Blueprint Machines. — When the advisability of installing a blueprint machine is considered, the governing factors should be the amount and private nature of the work, access to a professional blueprinter, and his prices.

With the cost of a horizontal machine, complete with washer and drier, around $1000, office room $2 per square foot (New York), and an operator at $75 per month, it will not be a saving investment, when the monthly bills at a printer's would run under $250 if figured at 2¢ per square foot.

A brief description of the various types of prints, with their prices, follows:

Blueprints, white lines on blue ground on paper

Minimum charge	.05 each
Charge per sq. ft.	.02, over 42″ .03
Specifications in lots of 100	.02 each
Small blueprints in lots of one hundred or more	$3.50 per 100

Blueprints, white lines on blue ground on cloth

Minimum charge	.15 each
Charge per sq. ft.	.07
In lots of 100 or more	$10.00 per 100

Brown Vandyke Prints, negative and positive on paper

Minimum charge	.15 each
Charge per sq. ft.	.08
On cloth per sq. ft.	.15
Minimum charge	.25 each

Blue Line Paper, from negative, blue lines on white ground

Minimum charge	.10 each
Charge per sq. ft.	.05
On cloth per sq. ft.	.10
Minimum charge	.15 each

Litho Black Prints, on paper

Quantity	1	2	3	4	5	or more
Price	10	9	7	6	5	per sq. ft.
On cloth	15	12	10	9	8	per sq. ft.

Blueprint Frame. — A simple and most inexpensive "field office" blueprint frame can be made, for use against a single sash window, with a cleated back-board, with felt pad glued to it, a wood bar across the center of the window, and a wedge. When ready for a print the bottom of the board rests against the bottom of the sash

and the upper part leans against the cross-bar. The tracing and print paper being dropped in behind the board, the latter is pushed up against the glass and the wedge dropped in between the back of the board and the cross-bar. This apparatus is without doubt twice as fast to handle and consequently is only half the work of the usual frame and works very well up to about 18″ x 24″ size. Some extra tins are required outside to keep the glass from being pushed out if puttied. The board back must be perfectly flat to give even contact and should have a cross-bar for the wedge to act against. The felt should be at least $\frac{1}{4}$″ thick and glued to the board.

A small mirror outside the sash will enable inspection for color of print without disturbing anything.

Files. — The most satisfactory files for tracings were found to be those with five or six drawers to a section, and for prints, those with three or four drawers to a section. All drawers should have a board across the top at the back, and spring clips at the front corners. (See Fig. 1.)

These files can be obtained with drawers measuring 26″ x 38″ inside which will be the correct size for 24″ x 36″ drawings and will divide for the smaller sizes as shown in Fig. 1. For the largest standard size drawings (30″ x 41″) a file can be obtained measuring 32″ x 42″.

For the protection of the most valuable drawings or tracings from fire or theft, file drawers can now be obtained built in light steel safes of a kind approved by the Board of Fire Underwriters. Another method is to have a Van Dyke print made from each tracing and sent to a depository in a different building.

Ink Bottles. — The ordinary ink bottle has too small a neck for satisfactory use. In dipping a pen in it for

printing, ink is usually smeared on the holder and fingers. A much better arrangement is to buy bottles with larger mouths and corks through which the quills from the old bottles can be run. The drawing ink should then be bought by the pint and the small bottles filled as required.

Pens. — The most convenient for both ruling pens and compasses are the ones that have a spring blade

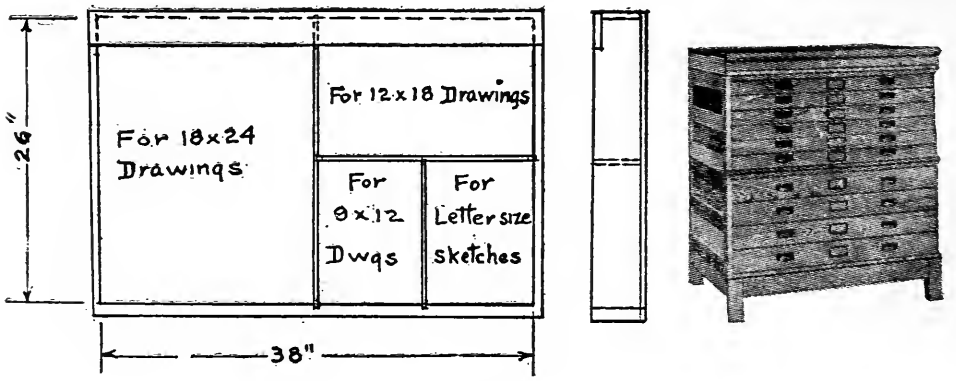


Fig. 1

and which do not require resetting after cleaning and closing.

For printing, the ball point pens seem to work the best, and faster printing can be done with them. Use the ordinary commercial styles for the larger letters, and for the lower case type and figures use a finer pen.

Pencils and Sharpeners. — In drafting rooms where the ordinary wood and lead pencils are used, a convenient instrument is a rotary sharpener, which makes a long taper on the wood part of the pencil and leaves the lead unsharpened. The latter is then finished to suit on the sandpaper board.

A very satisfactory arrangement and time saver is the double end holder with separate leads, a hard one

being kept in one end and a soft lead in the other. A turn of the end then loosens and tightens the lead for adjustment and a sandpaper board does all the sharpening necessary.

The sandpaper board is cleaner than a file, because it holds the lead on its surface.

Scales. — The most convenient and quickest to handle are the single flat scales with both bevels on one side and only one scale to a bevel reading from right to left. This for the $\frac{3}{8}$ and $\frac{3}{4}''$ scales, and the $1\frac{1}{2}$ and $3''$ scales.

To the above should be added one open divided scale, with inches and 32ds on one side and an open divided decimal scale to inches and 50ths on the other side, the tenth marks being longer and marked .1 to .9.

The $\frac{1}{8}$ and $\frac{1}{4}''$, $\frac{1}{2}$ and $1''$, scales can be made of the same style but two scales to a bevel. Except the last, these will have to be made to order, but the extra convenience will repay the slight additional expense.

A small brass knurled knob screwed into the center of each scale will be found very useful for handling it.

The triangular scale is a nuisance for drafting, but convenient for the engineer who does not want a lot of single scales around. A spring clip snapped over the top side will keep the scale in use where it can be readily found.

For accurate scale mechanical work, such as jigs and fixtures, tools and gun parts, the steel scale should be used. A sharp and hard pencil point can then be run down the proper groove and the layout mark made where wanted.

Tables. — For small and medium size drawings a very convenient and satisfactory table, both as to price and operation, is found as shown in Fig. 2. An extra table

without rack and drawer is used alongside the first for reference prints.

If space is limited the reference table can be lower and partly under the drafting table top. Also in emergency a second drawing can be started on it if it is not desirable at the time to clear the regular board.

For large drawings, where the floor space and resources warrant it, larger and heavier tables can be provided, the most satisfactory probably being the long, flat table with tilting board at the left and drawers at the right side. Not over two small drawers for tools and books and one large drawer for drawings are advisable. Otherwise, prints and drawings which should be in the general files will collect in them and cause loss of time, and trouble before being found.

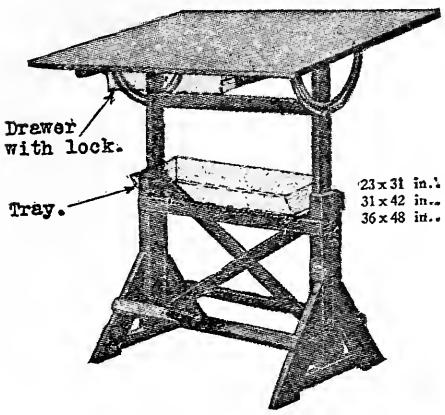


FIG. 2

Thumb Tacks. — Small tacks with thin pins and heads are the most satisfactory both for ease in removing and least damage to the boards.

T Squares. — Those of hard wood with fixed heads and celluloid edges are the best for general use if it is not desired to go to the expense of fitting the boards with the sliding straight edge kept parallel with cords and pulleys. If the latter is used it should have the cords below the top of the board and have a wood grip screwed to the center for handling it and forming a place for the scale, pencil, and rubber.

Tracing Cloth. — It is advisable to order tracing sheets cut to the sizes required and with the border lines, material

list headings, and title forms printed on them. This will greatly improve the appearance of the work, and the cost will be less than buying cloth by the roll when the saving in cloth and time is considered.

II

ORGANIZATION

The drafting force may be divided as required into groups or squads for the following classes of work:

Architectural and
Structural
Electrical
Mechanical
Topographical
General and Tracing.

Each group should be in charge of a designated head, through whom all work for that group should be given and thereafter followed up.

The drafting work should be apportioned to give each group its special class of drafting whenever possible.

The head of any group should coöperate with the others in the use of his men when requested, and it can be done without detriment to his own work. In such cases the draftsmen thus temporarily assigned to another group will be under the direction of the head of that group until the completion of the work.

Administration. —

Hours.

Notification of change of address.

Notification, or permission for, intended absence.

Notification of special experience or ability, including foreign languages spoken.

Suggestions welcomed for improvement in apparatus or methods.

Rules as to smoking. Not permitted in some drafting rooms owing to interference with the work.

Overtime.

Above are a few suggested "Heads" for subjects on which no two offices agree, and which are therefore best covered by special instructions in each case.

Men. — A certain Iron Master taught us that success in a business mostly depended on the proper selection of men and their assignment to the class of work for which they were best adapted.

Nowhere can this be better demonstrated than in the conduct of an engineering and drafting force. A careful study of characteristics and training will be necessary and some trials at different kinds of work may be required to place some of the men. But this will be time well spent.

It has been demonstrated in companies which train their own men that certain types could not be developed into satisfactory draftsmen but made excellent tracers. Others who were not successful as designers did very good work as estimators. Still others who passed as excellent designers, having ability, boldness, and originality, were very liable to make many small errors and their work in consequence required very careful checking. Then a careful, thorough type who had the qualities to make excellent checkers were largely found to fail on work requiring original designing ability.

Such changes in the work of men, made with tact and judgment and with due analysis of the work as well as

the men, are bound to result in more and better work and a large decrease in the labor turnover.

The more varied the work, with the consequent larger force on which to work, the greater the proportionate results to be attained.

Men — Qualifications. — The five chief qualities a draftsman should cultivate are: accuracy, technique, speed, economy, and neatness.

Accuracy is the greatest of these. A mistake should be considered as a reflection on character, and an effort should be made to get in the habit of doing accurate work.

Technique should be studied thoroughly, as without it work appears amateurish and invites lack of confidence.

Speed in drafting is the result of mental processes as well as manual dexterity. It naturally follows quick thought when the subject is understood and technique is at command.

Economy. Speed will cover about half of this qualification. The other half is to be attained by close attention to what details, dimensions, and shading are essential and what are not.

Neatness is placed last from an efficiency standpoint when weighed with the other qualities. It should be developed into a habit, and will usually be noted in the work of men possessing the other qualities.

Men — Output. — With the great increase in rents, salaries, and equipment, a drafting room is now a more expensive part of an organization than ever before. Every draftsman should realize this, and that his output is given keener scrutiny than ever, and even weighed against the rental value of the space occupied. He should therefore try to save his employer what time he can on his work,

for the man who turns out the most of satisfactory work is the one who is kept on during slack times.

It is a conservative estimate to place at 20% the time that could be saved on the average draftsman's work by a stricter attention to the omission of *nonessential* detail, shading, and dimensions, and in many places the substitution of a note for a detail, particularly in calling for standard equipment.

Perception of what is essential and what not should be developed, so that the work turned out will be a mechanical drawing and not a "picture."

The ability to do this is particularly valuable as a time saver in the early stages of a drawing, before the design is approved, as any unnecessary work done up to this approval is frequently wasted if the design is changed.

Work is often seen which at first glance appears to be all that could be desired, but closer inspection reveals a lack of essential mechanical information necessary for the manufacture of the matter shown. This lack is covered up by nonessential information, shading, useless dimensions and detail of standard fittings, such as bolts, nuts, valves, etc., and makes of the drawing what is termed in factory drafting rooms a "pretty picture."

These remarks do not apply to drawings for illustration, advertising matter, or Patent Office work, where the pictorial effect is desired.

III

GENERAL DIRECTIONS

General Directions. — Two important rules should be kept in mind to insure satisfactory work in the drafting room:

First. — Arrange and perform the work in the order of its importance.

Second. — Do not start new work until the completion of old, unless the latter is held up for information or some other very good reason.

Work Orders. — Authorizations for drawing work should be issued by the chief draftsman on special forms, such as shown in Part III, and which shall give name of part or section of plant for which the work is intended, location, character of work, for whom intended, date, account or charge number, directions for and disposal of the completed work.

Copies of authorizations to the number required for office routine will be made, the usual distribution being to estimating department, engineer, chief draftsman, and draftsman.

The draftsman's copy has on reverse side a space in which to add directions as to titles, drawing numbers, and space for draftsman's time for cost account. The draftsman's copy follows the drawing throughout and is returned with completed drawings to chief draftsman for record and file. After completion of work any of the other copies may be destroyed as desired, their purpose being to assist in following up the work.

Much time is wasted and heavy drafting expense incurred when important proposed work is not first sketched out and discussed before any drafting is done. Some offices even make it a practice not to discuss such work until the tracings are finished; not realizing the time and money lost in making the changes which invariably follow this method, and the loss of interest and initiative on the part of the draftsman who has his supposedly completed work changed again and again.

At these discussions the endeavor should be made to get the source of information as close to the drawing board as possible, to avoid loss of value in transmitted information. Granting the information has come to the Chief or Squad Draftsman in good form for, let us say, an article to be manufactured, he is expected to make the drawing with due regard to all operations which follow, such as, tool making, pattern making, foundry work, machining, assembling, and, last but not least, selling. As few men are familiar with all these processes, preliminary sketches or prints and discussions should touch all these departments with a view to obtaining the best information relative to economical and rapid progress of the work through each.

With proper organization and handling, this can be done without friction and the results in the final product should justify the initial trouble and expense.

With sufficient new work it is advisable to have a man or men assigned to this class of preliminary work, preparing pencil sketches for discussion and approval of those in authority, before any real drafting work is attempted. Revised sketches should then be issued with the work authorizations and be filed with them when the drawings are completed.

Starting a Drawing. — Return to the proper source all work orders, drawings, reference prints, and data relating to the last completed job.

Write in pencil, on the lower right-hand edge of the paper, the name of the drawing, plant, order number of the work, and your initials.

Keep the work one and one half inches from the left edge of the paper or cloth, to leave room for binding of prints.

Do not crowd the views or parts shown. Leave space on detail sheets near title, for additions and revisions.

Scale. — The scale to which a drawing should be made is the one just large enough to show clearly the parts wanted, and to accommodate without crowding the dimensions and notes.

Use $\frac{3}{8}''$, $\frac{3}{4}''$, $1\frac{1}{2}''$, $3''$, and full-size scales for mechanical work.

Use $\frac{1}{8}''$, $\frac{1}{4}''$, $\frac{1}{2}''$, and $1''$ scales for architectural work.

Where more than one scale is used on the same drawing, give the scale under each part as well as in the title box.

Arrangement. — In general, draw plan at the left side of the sheet, with front elevation below and end elevation to the right.

Avoid unnecessary ornamental and shading work that will increase the drafting time and cost.

When more than one sheet is required for a piece of work, if practicable keep the sheets of uniform size.

When details call for several classes of materials which would be supplied by different companies, group the parts to be made of like material, and show each group on a separate sheet or sheets.

Do not crowd the work. If detailing several small parts on one sheet, use a drawing sheet large enough to leave room for the addition of two or three more parts and for revisions. Draw details in their natural position and to the same "hand" as seen in the assembly drawing.

Dimensions. — Give length and breadth dimensions on the plan, and dimensions of height or depth on one of the elevations only.

Do not repeat dimensions on the different elevations or projections.

Give over-all dimensions.

Give dimensions in inches up to 72″, after that in feet and inches.

Center lines are often only imaginary lines, and for that reason, on mechanical work, it is better to work from a finished edge or surface.

Use thin broken lines for dimension lines and do not place them near construction lines.

Do not cross dimension and construction lines when it can be avoided.

Make notes about dimensions, above the construction lines rather than below.

Make notes and figures to read from not more than two directions; namely, bottom and right side of drawing.

Make notes and figures read from the same direction that the drawing reads to which the notes and figures apply.

Keep notes outside the objects drawn and use a light pointing line to the part to which reference is made.

Group the notes referring to the same detail.

Do not write notes across dimension or construction lines.

Be consistent and follow the same system of making notes and dimensions throughout the work.

Figures. — Make fractions with a horizontal dividing line, thus: $\frac{1}{2}$, not 1/2.

Use single-stroke inclined figures.

Make whole numbers about $\frac{7}{64}''$ to $\frac{1}{8}''$ high.

Make fractions with each figure about $\frac{5}{64}''$ to $\frac{3}{32}''$ high.

Make numbers of drawings about $\frac{5}{16}''$ high.

On pencil work for preliminary prints, be sure that the figures are made dark enough to print well.

Lettering. — Few things add so much to the appearance of a drawing as well-lettered notes and figures properly

placed. The art of making good letters and figures requires some study as well as practice, for the picture of a perfect letter or figure must exist in the mind before it can be made with the hand. The first step, then, is to memorize the appearance of a perfectly formed alphabet and set of figures, of the style to be used, and then practice the strokes necessary to make them. Single straight strokes should be tried first, then the *o*, *c*, and *s*, which will cover most of the strokes also required for the figures.

The most common faults to be guarded against are too much space between the letters of a word and not enough space between the words.

A fine but stiff pen will be found the most satisfactory for small lettering and figures, and a ball point pen for the larger sizes, titles, etc.

The use of single-stroke inclined Italic letters $\frac{7}{64}''$ to $\frac{1}{8}''$ high for capitals, and $\frac{5}{64}''$ to $\frac{3}{32}''$ for small letters, is recommended for appearance, ease, and rapidity of execution.

The style of letter in the first example below, called the Italic, is the simplest and quickest to make, as it requires the least number of strokes. When a straight line will do, it is used and an entire absence of extra curves and curls is aimed at. To avoid blurring where lines meet at a point, both strokes should be drawn toward the point whenever possible, and, for speed, a pen so fine that it sticks in the paper should not be used. It is better to use a slightly coarser pen and make the letters a trifle larger.

The second example, of the same general type of letter but made in a vertical position and with a heavier line, is called the Gothic alphabet and is gaining in favor. It is harder to make after using the Italic, but practice with the work squarely in front of one, and both eyes focusing at

the same angle, will overcome the trouble. This type looks better in the titles and can be well executed by using a piece of cross-section paper under the tracing cloth.

The above applies to working drawings for manufacturing and construction purposes. Drawings for illustration and advertising matter are in a different class and there more elaborate letters are frequently desired and used.

The third example is an adaptation of the Roman alphabet used by architects. Several modifications are seen and like the other alphabets they are made in both compressed and extended form, the underlying idea seeming to be equal blank spaces between the lines composing the letters, thus producing a pleasing uniform effect rather than extreme legibility. The round letters, such as *o*, *c*, and *s* are inclined to the right or left to suit the space, and when two *o*'s come together they are interlocked.

These three examples may be said to cover present requirements and all should be made freehand, as the day of the drawn letter has passed.

EXAMPLE 1

ABCDEFGHIJKLMNOPQ
RSTUVWXYZ&$.-':!
1234567890

ABCDEFGHIJKLMNOPQRSTUVWXYZ
1234567890&$

abcdefghijklmnopqrstuvwxyz 1234567890

Example 2

ABCDEFGHIJKLMNO
PQRSTUVWXYZ, &c
1234567890.

ABCDEFGHIJKLMNOPQRSTUVWXYZ
1234567890

abcdefghijklmnopqrstuvwxyz
1234567890.

Example 3

Naming of Parts and Drawings. — It is very important that care be given to this matter as noted under filing, and general instructions issued covering this subject. Otherwise different names will creep into use for the same object and much confusion will result in getting prints out of the files, in discussion, and ordering of material.

Titles. — Name of the drawn parts should be the most prominent, company's name next, and data last. Whether the company's name or the subject-matter should be first is an open question; probably most engineers would say that to give the subject the most prominence would require it to be put at the top of the title frame, but this splits the information to be filled in, by insertion of the company's name at this place.

If the latter is kept in sufficiently small type, the name of the subject-matter can still be given prominence if it does come second, and this seems to make a better-looking title as a whole. When titles, borders, and material list headings are printed on the drafting sheets and the practice is made of cleaning tracings with benzine, the printing should be specified to be done with ink, which will not be affected by such cleaning.

It is important that care be given to the assignment of all drawing titles, as on them will depend the success of the alphabetical index. Titles, therefore, should be assigned by one person only.

For ready reference to any drawing by this system and a card index, the following rules should be observed:

First, Divide the title into three lines or parts, X, Y, Z, as follows:

X, Name of the part drawn. Name of part or machine to which it belongs.

Y, Name of section, subdivision, or group to which it belongs.

Z, Name of plant or location in which it belongs.

Second, Make the first word of each part of the title the true name of the object drawn, machine, section, or plant, as the case may be.

Third, Index by the name word of each section of the title. Never index by the adjective.

EXAMPLE: Assume a company operating three plants, known, we will say, as "Albany," "Buffalo," and "Rochester" plants. Each consists of X factories known as "A," "B," and "C," etc. Part to be indexed being "cylinder head of 6″ x 8″ blower engine" in "C" factory of "Buffalo" plant. Proceed to divide and assign the title in three parts, which, under the rules given, will read:

First line—CYLINDER HEAD—BLOWER ENGINE—6″x8″
Second " —C FACTORY
Third " —BUFFALO PLANT

It will be noted that the first word of each part of the title is the true name of the part, section, or plant, as the case may be, and this fulfills the conditions for successful indexing by the alphabetical method.

The drawing number will then be found in the card index, under division "Buffalo Plant," subdivision, "C Factory," and cross-indexed in this subdivision under "C" for cylinder head, and "B" for blower engine. See index card forms.

To insure correct titles and proper indexing, the person assigning titles should write them on the reverse side of the original work-order forms, in the space provided for the purpose, and at the time the drawing numbers are

assigned. Draftsmen will then copy those titles on the drawings without change.

Tracing. — Tracings are to be made on the rough side of the cloth. Start at the top of the sheet and keep the work about $1\frac{1}{2}''$ from the left-hand edge, to allow for binding the prints in sets.

Trace center lines, curves, vertical, and horizontal lines in the order given. If cloth from the roll is used, trace border lines and titles last. A little ingenuity in doing the work will obviate the necessity of waiting for the ink to dry.

Keep pens properly ground; not sharp enough to cut, but thin enough to make the ink flow properly. Lines made with a single stroke save time.

Erasures are to be made with rubber only. Sand rubbers are not to be used.

The parts of the object that lie nearest the observer should be traced first and with the heaviest lines. This brings out the object and makes the drawing easier to read. The dotted lines, showing the invisible parts, will then be traced and confusion of these lines avoided.

When curves run into straight lines, the former are inked first, as it is then easy to make an exact meeting with the ruling pen. Outside of lettering, nothing betrays the novice so quickly as poorly executed tangent lines.

When the practice is made of keeping pencil drawings after they have been traced, the tracer should write his initials, date traced, and drawing number in the right-hand lower corner of such drawings.

Signatures. — Every finished drawing or tracing is to be signed with the initials of the draftsman, tracer, and checker who has worked on it.

Every drawing is to be signed "Approved" by the chief engineer, or whoever is sponsor for that drawing.

For estimating purposes on rush work only, preliminary prints may be issued before drawings are checked or approved. In that event all such prints should be stamped "PRELIMINARY," and one kept for record as noted under "RECORD PRINTS."

Calculations. — On design work calculations will be made in a book provided for that purpose on application to the file clerk.

Commence each note or calculation with date, name of drawing, and separate by a line notes relating to different drawings.

Make calculations and notes in a neat and legible manner and so marked as to be readily understood by others.

Catalogues. — Necessary catalogues can be applied for through the file clerk, who will obtain them as required and file and index them under manufacturers' names and names of articles. This file should be kept up to date with new issues of catalogues as they appear.

A receipt card should be signed when catalogues are taken from the files, and they are to be returned promptly to the files after serving their purpose.

Checking Prints. — All drawings shall be checked by checkers or squad foremen. For this purpose a check print shall be made when the drawing warrants it.

Correct matter shall be marked with yellow crayon and corrections with red crayon. After corrections have been made, the check prints are to be delivered to the file clerk for filing with the record prints.

Check prints are not to be taken from the drafting room, and receipt cards must be signed when they are taken from the files.

Compass Direction. — Maps and plant arrangement sheets of the same plant are to be made uniform as to compass direction. If not otherwise required, North will be toward the top of the sheet.

Show True North by a solid or full arrow head with an E. & W. line.

Show Magnetic North by a half arrow head on that side of the line toward the declination.

Field Drawings. — Field drawings should be made to these standards and should bear the date made and the approval of the resident engineer.

Title and number space should be left for filling in at the main office. Local title and number should appear over the regular title box, with name of plant and section or purpose for which the article is used.

Three prints or one original tracing of all field drawings that show any part of the plant or apparatus that has been built, or is to be built, should be noted accordingly and sent to the engineering division at the main office for filing.

It is important that field drawings be made to the sizes given, as the main office files are made and fitted for these sizes.

Field offices will see that their old prints are destroyed as soon as possible after receipt of revised prints. Useless work and expense will be avoided by careful attention to this matter.

Fit Dimensions. — In specifying fits on mechanical drawings, give limits expressed as plus or minus after the dimension figures.

EXAMPLE: $1.785 \pm .001$

For fit allowances, see machinists' handbooks.

Filing. — A file clerk should be in charge of the files and the recording of incoming and outgoing drawings, prints, and catalogues. He should see that titles and numbers are properly entered in his record book and on the index cards.

All drawings should be cross-indexed as to plant, division or section, and name of part shown.

The record book should show, in remarks column, the numbers of superseded and superseding drawings, also about cancellations of drawings with dates.

Drawings will be indexed and filed under the following classifications, indicated by the first or series number, followed by the size letter and serial number:

1–B–1278 would indicate drawings made at the main office.

2–B–etc. would indicate drawings made at branch offices, or in the field.

3–B–etc. would indicate miscellaneous foreign drawings of apparatus in use.

4–B–etc. would indicate miscellaneous foreign drawings of apparatus filed for reference only.

Series numbers to be continued as required. Serial numbers start with 1 for each series, as missing drawings are thus most easily detected.

The letter following the first number indicates the size of drawing, as follows:

"A," $8\frac{1}{2}'' \times 11''$, sketch or data size.
"B," $12'' \times 18''$.
"C," $18'' \times 24''$.
"D," $24'' \times 36''$.
"E," $30'' \times 41''$.

The number following the letter is the serial number and indicates the position of the drawing in the file.

File drawers will be marked with the series name and number, size letter, and range of serial numbers of the drawings they contain.

Tracings, record prints, sets of prints, and the classified prints will be kept in separate files.

Sets are to be kept up to date with the latest revised prints.

Drawings, tracings, and prints taken from the files are to be returned promptly after being used. Receipt cards should be signed for tracings taken from the files, and for drawings and prints according to their importance.

When the filing system is to be decided upon, consideration should be given to the rate of growth and ultimate number of drawings that will be filed. If a few thousand will be the limit, the alphabetical and numerical system described will be satisfactory if the rules for titling and indexing are observed. Should it be decided, however, to provide for many thousands or an unlimited number of drawings, tracings, and prints, then one of the decimal systems should be adopted.

In the former case all the drawings of one size would be numbered consecutively and filed numerically — a missing drawing being instantly detected; or, the number being had, it will readily be found in its numerical position. Also, new files will only have to be purchased when files already on hand are *completely* filled.

In the decimal system all the drawings of one class, or order, or contract are brought together under one preliminary number and subdivided by following numbers separated by dashes, or letters having special significance for subdivision. This system has the advantage of bring-

ing all the drawings of one group together, although possibly of varying sizes, and it has the disadvantage of difficulty of detecting missing drawings, and the greater amount of file and floor space required, as there will be more drawers in process of being filled than with the first system.

Transmitting Prints. — A letter of transmittal must accompany the first issue of all prints and all subsequent issues of revised prints.

To avoid confusion in filing, a separate letter should be written for each general subject.

In all letters of transmittal, state:

1, Number of prints transmitted;
2, Numbers of the prints;
3, Date of last revision;
4, Title;
5, Name of plant;
6, Instructions covering the disposition of, and purpose for which the prints are issued (if revisions, instructions should cover the destruction or return of obsolete prints);
7, Information relative to features of construction, ordering of material, etc.

Material Lists. — On mechanical work it is customary to put the short material lists, or parts lists, on the assembly drawings, and the long lists on a separate sheet with a drawing number.

On architectural work it is better to make the material lists on special letter-size sheets of thin paper, which may be typed with a reversed carbon sheet at the back. Very good blueprints to the number required may then be made from these typed sheets. Such material lists

will bear the same number as the authorization or order for the work, and will be filed under this number, in a vertical letter file reserved for material lists and specifications. The same order number appearing on the drawing will then serve to bring all parts of the work together. A form for such material lists is given.

Specifications. — It is recommended that specifications be typed on thin letter-size paper, with a reversed carbon sheet at the back, and blueprints made from these sheets as with material lists. Such specifications will also bear the authorization or order number of the work, and be filed with the material lists. The order number on the drawing will then bring all parts of the work together. A form for such specifications is given.

It is possible to get a lower price for blueprinting these small sheets by having several of them printed on a larger sheet and then cutting up such sheets in your own office.

Old Drawings and Prints. — Do not let old drawings and prints accumulate on the reference boards. Return them promptly to the files after using or to the squad foreman for destruction, as the case may require.

Parts Lists and Details. — Give names under the respective parts drawn, with kind of material, finish, and number required for one unit below it.

When a material list with part numbers is used, place the part number in a $\frac{5}{16}''$ diameter circle above the name of the part, and give the material and number required in the material list only. The descriptive matter under the part will then consist of part number, name, and finish, only.

When details cover more than one sheet, part numbers should run through the several sheets, allowing at least

ten blank numbers to a sheet before starting to number the parts on the next sheet.

Patterns. — Make the following notes on all drawings requiring pattern work:

Under each casting drawn, note that pattern is to be marked with the company's initials placed over the drawing and part number. The drawing and part number thus combined will constitute the pattern number.

EXAMPLE: Mark Pattern $\frac{\text{A. B. C. Co.}}{\text{1–C–9990}}$

On each drawing requiring pattern work make the following note:

"Use metal letters and figures on patterns to mark castings."

"Mark the company's initials and pattern number on each piece of a pattern and core box."

All orders placed for material including castings should have clearly stated on them whether or not the patterns are to become the property of the purchasing company. If so, the grade of pattern work should be covered, and a clause inserted specifying that the patterns and designs are to be for the exclusive use of the purchasers. Disposition of the completed patterns should be covered, also the matter of insurance or responsibility if they are to be left on storage.

Pattern Record Book. — A book for this purpose should be kept by the department having charge of making purchases or ordering material from the drawings, and this book should be kept up by having entered in it all purchases or transfers of patterns. This work is anticipated on the drawings by having a pattern number assigned to every casting called for.

A form is given for a pattern record book, the left-hand

page of which is for the pattern record and the right-hand page for the transfer record.

It is important that this book be kept up to date, for, if allowed to fall behind, it will be found very hard to bring it up and trace and locate old patterns.

Preliminary Prints. — When prints are sent out before being checked or approved, they should in all cases be marked "PRELIMINARY," and the usual charge should be made in the record book.

Tracings from which preliminary prints have been made should be returned to the squad foreman for completion. They must not be filed unless so directed by him.

Record Prints. — A record print shall be kept of the first printing from every tracing and from each subsequent revision. Every such print shall be stamped "RECORD PRINT," followed by date and number: 1, 2, or 3, etc., in the order of printing.

Record prints will be kept in a separate file, and are not to be taken from the drafting room. A receipt card should be signed when they are taken from the files for use in the drafting room.

References. — All tracings should bear, in space for that purpose, references to name and number of related drawings, such as details to assemblies, and assemblies to general arrangement drawings. Where there are no assembly drawings, reference should then be made from details to the general arrangement drawings. The arrangement drawings should bear the numbers of all their assembly or detail drawings.

Revisions. — Revisions to drawings will only be made with the approval of the chief engineer's office, and an order should be issued similar to that for new work. Each revision should be marked with a letter in the body of

the drawing, also noted in the space provided for the purpose near the title. This note should consist of the mark letter, date, and brief description of the revision, followed by draftsman's and checker's initials.

Old prints of revised drawings (except record and check prints) shall be destroyed by the file clerk. In order that he may do this, a copy of all orders for revisions should be given him.

All prints from revised tracings should be stamped above the title "REVISED PRINT."

Void Drawings. — Tracings will only be made void with the approval of the chief engineer's office, and an order should be issued as for new work and revisions. This order should state from what date the tracing is void, give the name or number of the superseding drawing or tracing, if any, and state to whom new prints should be sent. Tracings made void as above will be stamped with the "void" stamp, dated and initialed by the chief draftsman, and have the number of the superseding drawing noted on them.

A copy of all orders for making drawings or tracings void should be given to the file clerk, so that he may destroy the extra prints in the file.

Copyright.[1] — Drawings can be copyrighted by application to the Registrar of Copyright, Washington, D. C., for blanks, and putting the proper marks on drawings. These are a "C" in a circle, with initials and date, if full name appears elsewhere on the sheet; otherwise, the full name under the circle with the (C), and the date. A copy of the drawing, photo, or print so marked should then be sent, with the blank properly filled out and an enclosure of one dollar to the Registrar of Copyrights, Washington, D. C.

[1] See the following page for drawings qualified for copyright.

COPYRIGHT NOTICE

Extract from the Act of March 4, 1909, respecting the Copyright Notice

"SEC. 18. That the notice of copyright required by section nine of this Act shall consist either of the word 'Copyright' or the abbreviation 'Copr.,' *accompanied by the name of the copyright proprietor*, and if the work be a printed literary, musical, or dramatic work, the notice shall include also the year in which the copyright was secured by publication. In the case, however, of copies of works specified in subsections (f) to (k), inclusive, of section five of this Act, the notice may consist of the letter c inclosed with a circle thus: © accompanied by the initials, monogram, mark, or symbol of the copyright proprietor: *Provided*, That on some accessible portion of such copies or of the margin back, permanent base, or pedestal, or of the substance on which such copies shall be mounted, his name shall appear. But in the case of works in which copyright is subsisting when this Act shall go into effect, the notice of copyright may be either in one of the forms prescribed herein or in one of those prescribed by the Act of June eighteenth, eighteen hundred and seventy-four."

APPLICATION FORMS

Maps. — For a published map, ask for Application Form "F."

Works of Art. — For a work of art (painting, drawing, or sculpture); or for model or design for a work of art, ask for Application Form "G."

Drawing or Plastic Work. — For a published drawing or plastic work of a scientific or technical character, ask for Application Form "I 1."

For an unpublished drawing or plastic work of a scientific or technical character, ask for Application Form "I 2."

Photographs. — For a photograph published for sale, ask for Application Form "J 1."

For a photograph of which copies are not reproduced for sale, ask for Application Form "J 2."

Fees. — The statutory fee for registration of any work, except a photograph, is one dollar, including a certificate of registration under seal. In the case of a *photograph*, if a certificate is not demanded the fee is fifty cents. In the case of several volumes of the same *book* deposited at the same time, only one registration at one fee is required.

Technical Journals. — Subscriptions should be made to the technical paper or papers best covering the work in hand.

These should be faithfully read, and such items or articles as apply should be preserved for future reference.

The following method can be recommended if the entire issue is not preserved: Bend up the staples in the back of book and remove the full pages that contain the matter of interest. These are to be punched and bound in a loose-leaf binder held together with brass fasteners. Shun the antiquated type that is sewed together, for new matter may be added every week or two. The weekly indexes should be bound in, with the articles in question checked on them. If the periodical publishes a semi-annual index, it should be included.

This practice will give one a valuable reference book for his chosen line of work and the pages so bound will not be as bulky or troublesome to keep as the complete files.

The few articles later wanted and which were not kept can be located as to issue by the index and consulted at a library.

After removing pages as described, the balance of the journal can be restored, the staples bent down again, and the paper put to any other use desired.

Diary and Notebook. — Notes and memoranda should be made in such a manner, with name, date, and description, that they mean something and are not merely "scraps of paper," which, if picked up a day or two later, are Greek even to the man who made them.

If the information is worthy of preservation, it should be made on a loose-leaf sheet for insertion in an indexed book and it will be surprising how soon such a book will become valuable. A diary should go with this book and a distinction made between notes of temporary and permanent value; the former going into the diary with information relative to changes in work or position, date of trips and particulars, names of men met, etc. The same size for the diary as for the notebook should be adopted and this not too small. Also, the same kind of diary should be used from year to year. A few sheets from the notebook can be slipped in the diary to save carrying both books. These sheets, when filled out, can be filed in the alphabetical notebook when convenient. What has been said of the indexing for drawings will also apply to this matter.

PART II

STANDARDS AND SYMBOLS

SAFETY STANDARDS
ABBREVIATIONS
AËRONAUTICAL TERMS
CROSS SECTIONS
DEFINITIONS
ELECTRICAL SYMBOLS
LINES
PATENT OFFICE SYMBOLS
PIPE FITTING SYMBOLS
RIVET SYMBOLS
STRUCTURAL MATERIALS — BREAKS
THREAD AND TAPPED HOLES
TOPOGRAPHIC SYMBOLS

SAFETY STANDARDS

Safety Standards. — Drawings and specifications for machinery or apparatus of any nature should cover the guarding of dangerous features such as gear, chain, or belt drives and around moving parts generally. Also, the guarding of high voltage electrical connections, etc.

Drawings and specifications for buildings should likewise cover the protection of all openings, elevated ways, stairs, ladders, or runways, with suitable railings, etc.

Most of the states have regulations covering these matters and copies of them can be obtained by application to the various Industrial Boards. Much valuable information on this subject can also be obtained from the publications of the Casualty Companies, notably the Fidelity and Casualty Company of New York and the Casualty Company of Maryland.

A lasting impression of the importance of this matter can best be obtained by a perusal of the workmen's compensation laws.

Text of these may be seen in Report of Bureau of Labor Statistics, U.S. Department of Labor, or for quick reference see *The World Almanac*.

ABBREVIATIONS

A.....Area
A. C.....Alternating Current
App.....Approximate
Amp.....Ampere

B.....Bore
B. M.....Bench Mark
Br.....Brass
Bz.....Bronze

C.....Core
C. C.....Center to Center
C. I.....Cast Iron
C. L.....Center Line
C. P.....Candle Power
C. S.....Cast Steel
Csk.....Countersunk

D.....Diameter
D. C.....Direct Current
Dr.....Dressed

E. H.....Extra Heavy
E. M. F...Electro Motive Force

f.....Finish
F. & D. ..Faced & Drilled
F. to F....Face to Face
F. H.....Flat Head
Fils. Hd...Fillister Head
F. P. M...Feet per Minute
F. S.....Forged Steel
F. W.....Full Weight (Pipe)

G.....Grind
G. & P....Grind & Polish

H. I.....Height of Instrument
H.....Harden
H. & G. ..Harden & Grind
H. G. & P. Harden, Grind & Polish
Hem.....Hemlock
Hor.....Horizontal
HP.....Horse Power

I.....I-Beam
I. D.....Inside Diameter
I. P.....Iron Pipe
I. P. T....Iron Pipe Thread

kg. .....Kilogramme
km. .....Kilometer
K. W.....Kilowatt. Keyway
K. S.....Keyseat

L.....Angle — Length
L. H.....Left Hand

Max.....Maximum
Min.....Minimum
Mal.....Malleable
M. I.....Malleable Iron
Mang.....Manganese
M. S.....Machine Steel
mm.....Millimeter
M. & F....Male & Female

N. S.....Nickel Steel

O. D.....Outside Diameter
O. H.....Open Hearth
O. H. S....Open Hearth Steel

P.....Polish
Pl.....Plate
P. C.....Point of Curvature
P. T.....Point of Tangency

R.....Rough
Req.....Required
R. H.....Right Hand
R. & L....Right & Left
Rev.....Revolutions
RPM.....Rev. per Minute

Sp.....Spruce
S. 4 S.....Surface 4 Sides
Std.....Standard

S. S.....Set Screwed

T. & G....Tongued & Grooved
T. P. I....Threads per Inch

V.....Volt
Vert.....Vertical
W. G.....Wire Gauge
W. I.....Wrought Iron
W. S.....Wrought Steel

X. H.....Extra Heavy
XXH.....Double Extra Heavy

Y. P.....Yellow Pine

SPELLING AND ABBREVIATIONS OF UNITS

Units of Weight and Measure from Circular No. 47, United States Bureau of Standards

"The spelling of the names of units adopted by the National Bureau of Standards is that given in the list below. The spelling of the metric units is in accordance with that given in the law of July 28, 1866, legalizing the metric system in the United States.

"Following the names of each unit in the list below is given the abbreviation which the Bureau has adopted. Attention is particularly called to the following principles:

"1. The period is omitted after the abbreviations of the metric units, while it is used after those of the customary system.

"2. The exponents '^{2}' and '^{3}' are used to signify area and volume, respectively, in the case of the metric units, instead of the longer prefixes, 'sq.' or 'cu.' In conformity with this principle the abbreviation for cubic centimeter is 'cm^3,' instead of 'c. c.' or 'c. cm.' The

term 'cubic centimeter' as used in chemical work is, in fact, a misnomer, since the unit actually used is the 'milliliter,' which has a slightly larger volume.

"3. The use of the same abbreviation for both singular and plural is recommended. This practice is already established in expressing metric units and is in accordance with the spirit and chief purpose of abbreviations.

"4. It is also suggested that, unless all the text is printed in capital letters, only small letters be used for abbreviations except in the case of A. for acre, where the use of the capital letter is general."

The list of the most common units of weight and measure and their abbreviations follows:

Unit	Abbreviation	Unit	Abbreviation	Unit	Abbreviation
acre	A.	dram, avoirdupois	dr. av.	ounce, avoirdupois	oz. av.
are	a	dram, fluid	fl. dr.	ounce, fluid	fl. oz.
avoirdupois	av.	fathom	fath.	ounce, troy	oz. t.
barrel	bbl.	foot	ft.	peck	pk.
board foot	bd. ft.	firkin	fir.	pennyweight	dwt.
bushel	bu.	furlong	fur.	pint	pt.
carat, metric	c	gallon	gal.	pound	lb.
centare	ca	grain	gr.	pound, apothecaries'	lb. ap.
centigram	cg	gram	g	pound, avoirdupois	lb. av.
centiliter	cl	hectare	ha	pound, troy	lb. t.
centimeter	cm	hectogram	hg	quart	qt.
chain	ch.	hectoliter	hl	rod	rd.
cubic centimeter	cm^3	hectometer	hm	scruple, apothecaries'	s. ap. *or* ℈
cubic decimeter	dm^3	hogshead	hhd.	square centimeter	cm^2
cubic dekameter	dkm^3	hundredweight	cwt.	square chain	sq. ch.
cubic foot	cu. ft.	inch	in.	square decimeter	dm^2
cubic hectometer	hm^3	kilogram	kg	square dekameter	dkm^2
cubic inch	cu. in.	kiloliter	kl	square foot	sq. ft.
cubic kilometer	km^3	kilometer	km	square hectometer	hm^2
cubic meter	m^3	link	li.	square inch	sq. in.
cubic mile	cu. mi.	liquid	liq.	square kilometer	km^2
cubic millimeter	mm^3	liter	l	square meter	m^2
cubic yard	cu. yd.	meter	m	square mile	sq. mi.
decigram	dg	metric ton	t	square millimeter	mm^2
deciliter	dl	micron	μ	square rod	sq. rd.
decimeter	dm	mile	mi.	square yard	sq. yd.
decistere	ds	milligram	mg	stere	s
dekagram	dkg	milliliter	ml	ton	tn.
dekaliter	dkl	millimeter	mm	ton, metric	t
dekameter	dkm	millimicron	m μ	troy	t.
dekastere	dks	minim	min. or ♏	yard	yd.
dram	dr.	ounce	oz.		
dram, apothecaries'	dr. ap. *or* ℥	ounce, apothecaries'	oz. ap. or ℥		

NOMENCLATURE FOR AËRONAUTICS

REPORT NO. 9

NATIONAL ADVISORY COMMITTEE FOR AËRONAUTICS

Introduction

For the information of those interested in aëronautics the following nomenclature has been prepared as a guide, with a view to eliminating the duplication of terms, the erroneous use of terms, and confusion of terms, and with a view to defining the principal terms which have come into use in the development of aëronautics. In the preparation of this nomenclature only those terms have been defined which are new and peculiar to this subject.

Aëronautical Nomenclature

Aërofoil: A thin wing-like structure, flat or curved, designed to obtain reaction upon its surfaces from the air through which it moves.

Aëroplane: See Airplane.

Aileron: A movable auxiliary surface used for the control of rolling motion — i.e., rotation about the fore and aft axis.

Aircraft: Any form of craft designed for the navigation of the air — airplanes, balloons, dirigibles, helicopters, kites, kite-balloons, ornithopters, gliders, etc.

Airplane: A form of aircraft heavier than air which has wing surfaces for sustentation, with stabilizing surfaces, rudders for steering, and power plant for propulsion

through the air. The landing gear may be suited for either land or water use.

Pusher. — A type of airplane with the propeller or propellers in rear of the wings.

Tractor. — A type of airplane with the propeller or propellers in front of the wings.

AIR-SPEED METER: An instrument designed to measure the velocity of an aircraft with reference to the air through which it is moving.

ALTIMETER: An instrument mounted on an aircraft to indicate continuously its height above the surface of the earth.

ANEMOMETER: An instrument for measuring the velocity of the wind or air currents with reference to the earth or some fixed body.

ANGLE:

Of attack. — The angle between the direction of the relative wind and the chord of an aërofoil, or the fore and aft axis of a body.

Critical. — The angle of attack at which the lift is a maximum.

Gliding. — The angle the flight path makes with the horizontal when flying in still air under the influence of gravity alone.

ASPECT RATIO: The ratio of spread to chord of an aërofoil.

AXES OF AN AIRCRAFT: Three fixed lines of reference; usually centroidal and mutually rectangular.

The principal longitudinal axis in the plane of symmetry, usually parallel to the axis of the propeller, is called the fore and aft axis (or longitudinal axis); the axis perpendicular to this in the plane of symmetry is called the vertical axis; and the third axis, perpendicu-

lar to the other two, is called the athwartship axis (or transverse or lateral axis). In mathematical discussions the first of these axes is called the x-axis, the second the z-axis, and the third the y-axis.

BALLONET: A small balloon within the interior of a balloon or dirigible for the purpose of controlling the ascent or descent, and for maintaining pressure on the outer envelope to prevent deformation. The ballonet is kept inflated with air at the required pressure, under the control of a blower and valves.

BALLOON: A form of aircraft comprising a gas bag and a car, whose sustentation depends on the buoyancy of the contained gas, which is lighter than air.

Captive. — A balloon restrained from free flight by means of a cable attaching it to the earth.

Kite. — An elongated form of captive balloon, fitted with tail appendages to keep it headed into the wind, and deriving increased lift due to its axis being inclined to the wind.

BANK: To incline an airplane laterally — i.e., to rotate it about the fore and aft axis. Right bank is to incline the airplane with the right wing down.

BANKING RUDDER: See Aileron.

BAROGRAPH: An instrument used to record variations in barometric pressure. In aëronautics the charts on which the records are made are prepared to indicate altitudes directly instead of barometric pressure.

BIPLANE: A form of airplane in which the main supporting surface is divided into two parts, one above the other.

BODY OF AN AIRPLANE: A structure, usually inclosed, which contains in a stream-line housing the power plant, fuel, passengers, etc.

CABRÉ: A flying attitude in which the angle of attacks is greater than normal; tail down; down by the stern — tail low.

CAMBER: The convexity or rise of a curve of an aërofoil from its chord, usually expressed as the ratio of the maximum departure of the curve from the chord as a fraction thereof. "Top Camber" refers to the top surface of an aërofoil, and "Bottom Camber" to the bottom surface; "Mean Camber" is the mean of these two.

CAPACITY:

Lifting. — The maximum flying load of an aircraft.

Carrying. — Excess of the lifting capacity over the dead load of an aircraft, which latter includes structure, power plant, and essential accessories.

CARRYING CAPACITY: See Capacity.

CENTER: The point in which a set of effects is assumed to be accumulated, producing the same effect as if all were concentrated at this point.

Of buoyancy. — The center of gravity of the fluid displaced by the floating body.

Of pressure of an aërofoil. — The point on the chord of an element of an aërofoil, prolonged if necessary, through which at any instant the line of action of the resultant air force passes.

Of pressure of a body. — The point on the axis of a body, prolonged if necessary, through which at any instant the line of action of the resultant air force passes.

CHORD:

Of an aërofoil section. — A right line tangent to the under curve of the aërofoil section at the front and rear.

Length. — The length of the chord is the length of the aërofoil section projected on the chord, extended if necessary.

CONTROLS: A general term applying to the means provided for operating the devices used to control speed, direction of flight, and attitude of an aircraft.

CRITICAL ANGLE: See Angle, Critical.

DÉCALAGE: An increase in the angular setting of the chord of an upper wing of a biplane with reference to the chord of the lower wing.

DEVELOPED AREA OF A PROPELLER: A layout of the area of a propeller blade designed to represent the total area of the driving face, in which the elements of area are developed as if unfolded onto the plane of the drawing (necessarily an approximation on definite assumptions, as no true development of the helix can be made).

DIRIGIBLE: A form of balloon the outer envelope of which is of elongated form, provided with a propelling system, car, rudders, and stabilizing surfaces.

Nonrigid. — A dirigible whose form is maintained by the pressure of the contained gas assisted by the car-suspension system.

Rigid. — A dirigible whose form is maintained by a rigid structure contained within the envelope.

Semirigid. — A dirigible whose form is maintained by means of its attachment to an exterior girder construction containing the car.

DISK AREA OF A PROPELLER: The total area of the disk swept by the propeller tips.

DIVING RUDDER: See Elevator.

DOPE: A general term applied to the material used in treating the cloth surface of airplane members to increase strength, produce tautness, and act as a

filler to maintain airtightness; usually of the cellulose type.

DRAG: The total resistance to motion through the air of an aircraft — i.e., the sum of the drift and head resistance.

DRIFT: The component of the resultant wind pressure on an aërofoil or wing surface parallel to the air stream attacking the surface.

ELEVATOR: A hinged surface for controlling the longitudinal attitude of an aircraft — i.e., its rotation about the athwartship axis.

ENGINE RIGHT OR LEFT HAND: The distinction between a right-hand and a left-hand engine depends on the rotation of the output shaft, whether this shaft rotates in the same direction as the crank or not. A right-hand engine is one in which, when viewed from the output shaft end, the shaft is seen to rotate anticlockwise.

ENTERING EDGE: The foremost part of an aërofoil.

FINS: Small planes on aircraft to promote stability; for example, vertical tail fins, horizontal tail fins, skid fins, etc.

FLIGHT PATH: The path of the center of gravity of an aircraft with reference to the air.

FLOAT: That portion of the landing gear of an aircraft which provides buoyancy when it is resting on the surface of the water.

FUSELAGE: See Body.

GAP: The distance between the projections on the vertical axis of the entering edges of an upper and lower wing of a biplane.

GLIDE: To fly without power.

GLIDER: A form of aircraft similar to an airplane, but without any power plant.

When utilized in variable winds it makes use of the soaring principles of flight and is sometimes called a soaring machine.

GLIDING ANGLE: See Angle, gliding.

GUY: A rope, chain, wire, or rod attached to an object to guide or steady it, such as guys to wing, tail, or landing gear.

HEAD RESISTANCE: The total resistance to motion through the air of all parts of an aircraft not a part of the main lifting surface. Sometimes termed "parasite resistance."

HELICOPTER: A form of aircraft whose support in the air is derived from the vertical thrust of large propellers.

INCLINOMETER: An instrument for measuring the angle made by any axis of an aircraft with the horizontal.

KEEL PLANE AREA: The total effective area of an aircraft which acts to prevent skidding or side slipping.

KITE: A form of aircraft without other propelling means than the towline pull, whose support is derived from the force of the wind moving past its surface.

KITE BALLOON: See Balloon, kite.

LANDING GEAR: The under structure of an aircraft designed to carry the load when resting on, or running on, the surface of the land or water.

LATERAL STABILITY: See Stability, lateral.

LEADING EDGE: See Entering edge.

LEEWAY: The angular deviation from a course over the earth, due to cross currents of wind.

LIFT: The component of the force due to the air pressure of an aërofoil, resolved perpendicular to the flight path in a vertical plane.

LIFT BRACING: See Stay.

LIFTING CAPACITY: See Capacity, lifting.

LOAD, FULL: See Capacity, lifting.

Reserve (or useful). — See Capacity, carrying.

LOADING: See Wing, loading.

LONGITUDINAL: A fore-and-aft member of the framing of an airplane body, or of the floats, usually continuous across a number of points of support.

LONGITUDINAL STABILITY: See Stability.

METACENTER: The point of intersection of a vertical line through the center of gravity of the fluid displaced by a floating body when it is tipped through a small angle from its position of equilibrium and the inclined line which was vertical through the center of gravity of the body when in equilibrium. There is, in general, a different metacenter for each type of displacement of the floating body.

MONOPLANE: A form of airplane whose main supporting surface is disposed as a single wing on each side of the body.

MOTOR: See Engine.

NACELLE: See Body.

NATURAL STABILITY: See Stability.

NOSE DIVE: A dangerously steep descent, head-on.

ORNITHOPTER: A form of aircraft deriving its support and propelling force from flapping wings.

PITOT TUBE: A tube with an end open square to the fluid stream, used as a detector of an impact pressure. More usually associated with a concentric tube surrounding it, having perforations normal to the axis for indicating static pressure. The velocity of the fluid can be determined from the difference between the impact pressure and the static pressure. This instrument is often used to determine the velocity of an aircraft through the air.

PROPELLER:

Developed area of. — See Developed area of a propeller.

Disk area of. — See Disk area of a propeller.

Right-hand. — One in which the helix is right-handed.

PUSHER: See Airplane.

PYLON: A marker of a course.

RACE OF A PROPELLER: The air stream delivered by the propeller.

RIB: See Wing.

RIGHT (OR LEFT) HAND:

Engine. — See Engine.

Propeller. — See Propeller, right-hand.

RIGID DIRIGIBLE: See Dirigible, rigid.

RUDDER: A hinged or pivoted surface, usually more or less flat or stream-lined, used for the purpose of controlling the attitude of an aircraft about its vertical axis when in motion.

SIDE SLIPPING: Sliding toward the center of a turn. It is due to excessive amount of bank for the turn being made, and is the opposite of skidding.

SKIDDING: Sliding sideways in flight away from the center of the turn. It is usually caused by insufficient banking in a turn, and is the opposite of side slipping.

SKIDS: Long wooden or metal runners designed to prevent nosing of a land machine when landing or to prevent dropping into holes or ditches in rough ground. Generally designed to function should the wheels collapse or fail to act.

SLIP: This term applies to propeller action and is the difference between the actual velocity of advance of an aircraft and the speed calculated from the known pitch of the propeller and its number of revolutions.

SOARING MACHINE: See Glider.

SPREAD: The maximum distance laterally from tip to tip of an airplane wing.

STABILITY: The quality of an aircraft in flight which causes it to return to a condition of equilibrium when meeting a disturbance. (This is sometimes called "Dynamical stability.")

Directional. — Stability with reference to the vertical axis.

Inherent. — Stability of an aircraft due to the disposition and arrangement of its fixed parts.

Lateral. — Stability with reference to the longitudinal (or fore and aft) axis.

Longitudinal. — Stability with reference to the lateral (or athwartship) axis.

STABILIZER: See Fins.

Mechanical. — Any automatic device designed to secure stability in flight.

STAGGER: The amount of advance of the entering edge of the upper wing of a biplane over that of the lower; it is considered positive when the upper surface is forward.

STALLING: A term describing the condition of an airplane which from any cause has lost the relative speed necessary for steerage-way and control.

STATOSCOPE: An instrument to detect the existence of a small rate of ascent or descent, principally used in ballooning.

STAY: A wire, rope, or the like, used as a tie piece to hold parts together, or to contribute stiffness; for example, the stays of the wing and body trussing.

STEP: A break in the form of the bottom of a float.

STREAM-LINE FLOW: A term in hydromechanics to describe the condition of continuous flow of a fluid, as

distinguished from eddying flow where discontinuity takes place.

STREAM-LINE SHAPE: A shape intended to avoid eddying or discontinuity and to preserve stream-line flow, thus keeping resistance to progress at a minimum.

STRUT: A compression member of a truss frame; for instance, the vertical members of the wing truss of a biplane.

SWEEP BACK: The horizontal angle between the lateral (athwartship) axis of an airplane and the entering edge of the main planes.

TAIL: The rear portion of an aircraft, to which are usually attached rudders, elevators, and fins.

TAIL FINS: The vertical and horizontal surfaces attached to the tail, used for stabilizing.

THRUST DEDUCTION: Due to the influence of the propellers, there is a reduction of pressure under the stern of the vessel which appreciably reduces the total propulsive effect of the propeller. This reduction is termed "Thrust deduction."

TRACTOR: See Airplane.

TRAILING EDGE: The rearmost portion of an aërofoil.

TRIPLANE: A form of airplane whose main supporting surfaces are divided into three parts, superposed.

TRUSS: The framing by which the wing loads are transmitted to the body; comprises struts, stays, and spars.

VELOMETER: See Air-speed meter and anemometer.

VOL-PIQUÉ: See Nose dive.

VOL-PLANE: See Glide.

WAKE GAIN: Due to the influence of skin friction, eddying, etc., a vessel in moving forward produces a certain forward movement of the fluid surrounding it. The

effect of this is to reduce the effective resistance of the hull, and this effect, due to the forward movement of the wake, is termed the "wake gain."

In addition to this effect the forward movement of this body of fluid reduces the actual advance of the propeller through the surrounding medium, thereby reducing the propeller horsepower.

WARP: To change the form of the wing by twisting it, usually by changing the inclination of the rear spar relative to the front spar.

WINGS: The main supporting surfaces of an airplane.

WING LOADING: The weight carried per unit area of supporting surface.

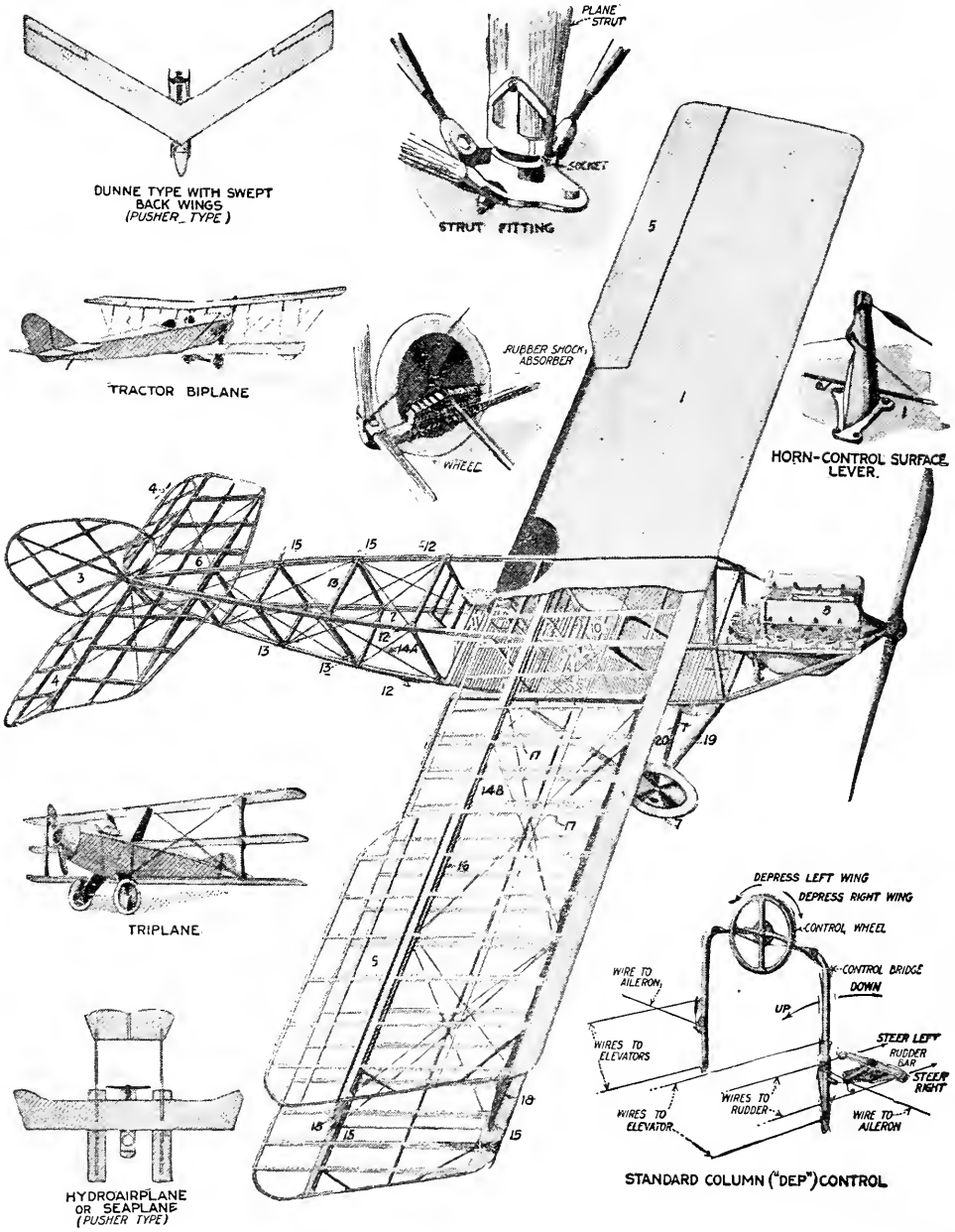
WING RIB: A fore and aft member of the wing structure used to support the covering and to give the wing section its form.

WING SPAR: An athwartship member of the wing structure resisting tension and compression.

YAW: To swing off the course about the vertical axis, owing to gusts or lack of directional stability.

Angle of. — The temporary angular deviation of the fore and aft axis from the course.

In connection with the nomenclature of the Advisory Committee, the following cuts of airplanes with their part names should prove useful and are reproduced by permission of the *American Machinist* and the *Aircraft Mechanics Handbook.*

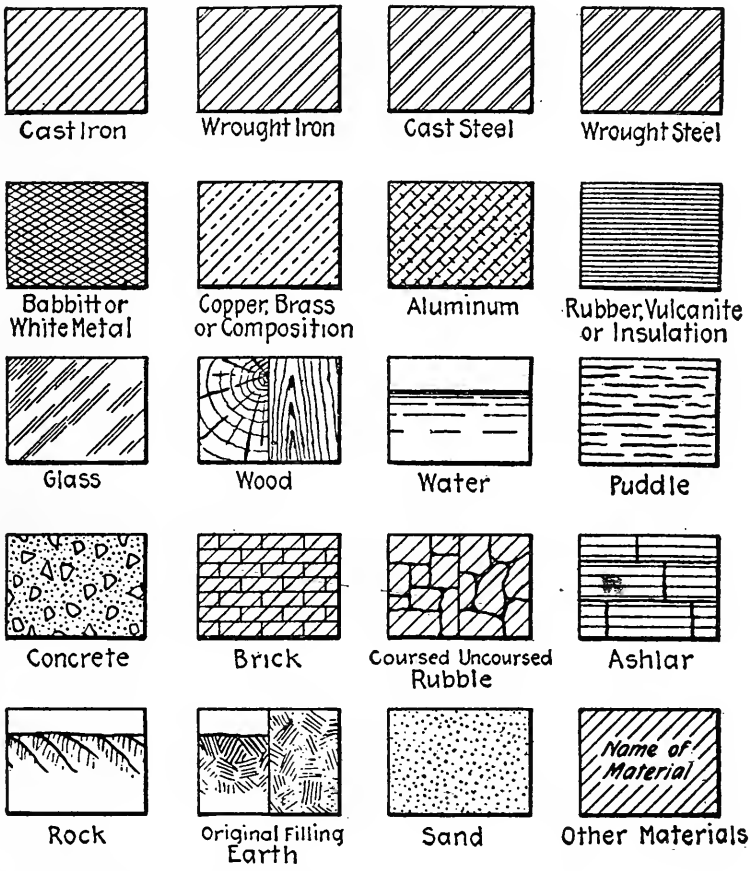


No. 1-Upper plane
" 1A- Lower plane
" 2-Fuselage or body
" 3-Rudder
" 4-Elevator
" 5-Aileron
" 6-Horizontal stabilizer
" 7-Wheel
No. 8-Engine
" 9-Propeller
" 10-Obeserver's or passenger's seat
" 11-Pilot's seat
" 12-Longeron
" 13-Fuselage strut
" 14A-Fuselage truss wire
No. 14B-Internal draft wire
" 15-Socket
" 16-Plane or wing spars
" 17-Ribs
" 18-Wing strut, (front and rear)
" 19-Landing gear strut
" 20-Axle

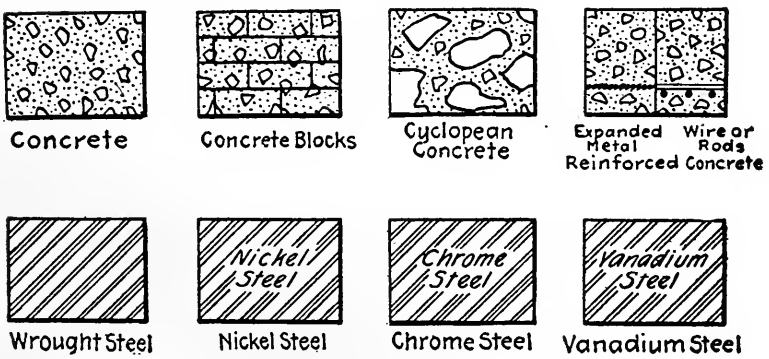
TYPICAL AIRPLANES AND DETAILS OF CONSTRUCTION

CONVENTIONAL SYMBOLS—CROSS-SECTIONS

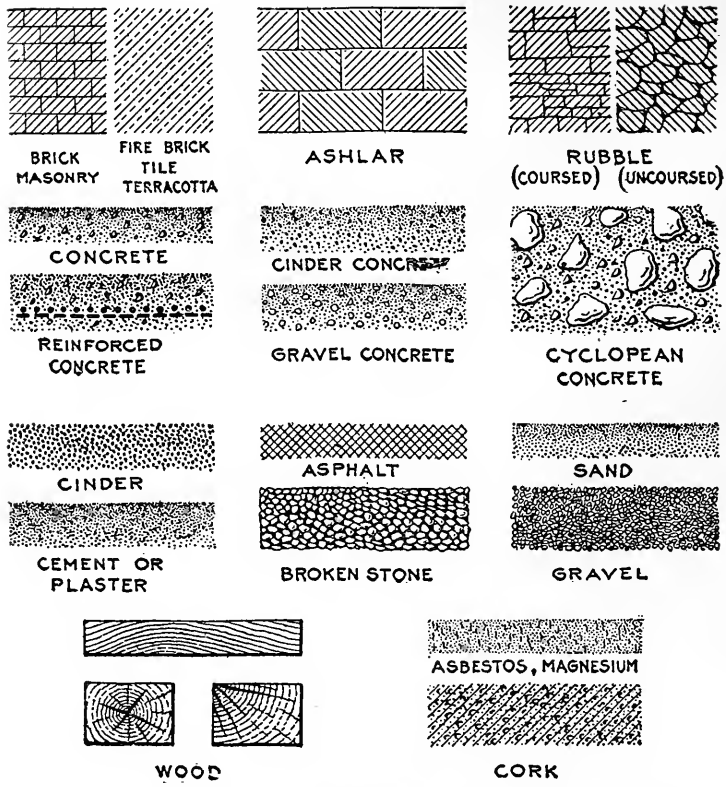
Reported by the Committee on Standard Cross-sections and Symbols, December, 1914. The American Society of Mechanical Engineers.



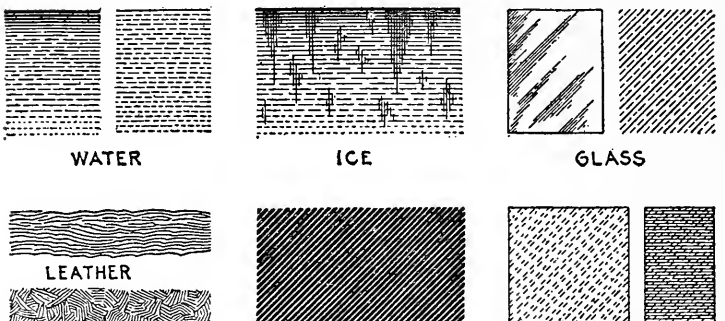
RECOMMENDED STANDARD CROSS-SECTIONS

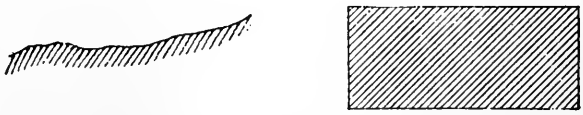


TYPICAL SUBDIVISIONS



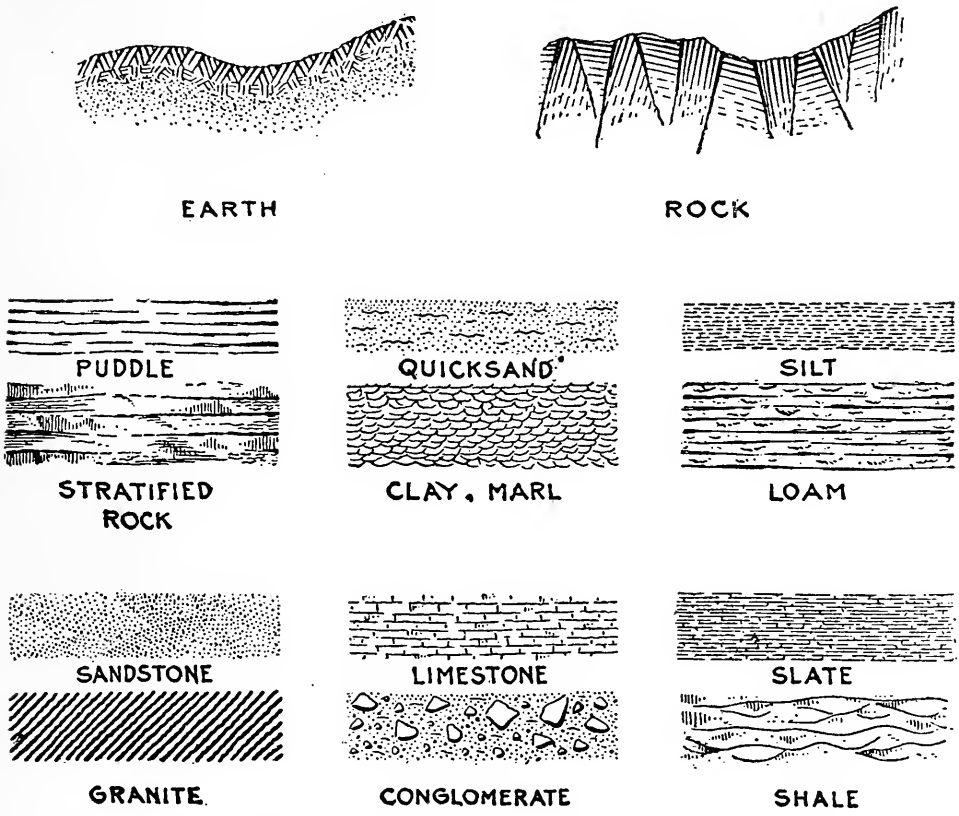
Symbols for Building Materials





Miscellaneous Symbols

Geological Symbols. — From Report of Committee on Cross-sections A. S. M. E., and following those used by the U. S. Geological Survey.



Symbols for Geologic Formations

DEFINITIONS

Definitions of directions for shop operations frequently given on drawings:

Anneal. — To refine the structure of metals by heating and cooling slowly, which makes them more ductile, increases the tensile strength, and in castings, also removes strains.

Babbitt. — To pour a mixture of tin, antimony, copper and lead into a bearing as for a bushing.

Bevel. — To slope or remove sharp edges.

Bore. — To cut a hole with a tool as distinguished from a rough hole in a casting formed by a core.

Braze. — To unite metals with spelter or hard solder consisting of zinc and copper.

Bush. — To fit a lining or ring of metal in a hole to take the wear of a moving part.

Broach. — To form a hole with a serrated tool of that name and which operates with an endwise movement, as distinguished from the rotary movement of a drill.

Caulk, or Calk. — To fill joints or seams to prevent leakage.

Camber. — To curve the surface of a timber, as the deck beams or carlins of a boat, to assist in running off water.

Case Harden. — To harden the outer surface of iron or steel.

Chamfer. — To remove sharp edges with a flat cut, usually applied to timber. To bevel.

Chill. — To harden the outer surface of castings by quick cooling.

Chip. — To remove lumps or rough spots with a cold chisel and hammer.

Counterbore. — To bore the outer part of a hole to a larger diameter than the inner.

Countersink. — To bevel the outer edge of a hole, as for a rivet or bolt head of countersunk form.

Core. — To form a hole or recess in a casting, with a portion of the pattern of that name.

Dovetail. — To make a joint of that shape, usually in wood.

Dowel. — To fasten with pins of that name.

Drive. — See Fit.

Face. — To finish a flat surface, as in a lathe or planer.

Fillet. — To fill sharp corners to a radius, as on patterns and castings.

FITS. — The following definitions for the different fits are arranged in the order of their tightness. For uniform results it is better to designate the fit by the sizes of the parts, expressed to a three or four place decimal with limits, full directions for which can be found in the handbooks.

Running fit. — To fit parts so that they may move and run freely; as a shaft in bearings or a loose pulley.

Push fit. — To fit parts so they may be pushed together by hand.

Wring fit. — To fit parts so they may be turned or wrung to place.

Drive fit. — To fit parts so that blows, with a hammer or sledge, are required to get them to place.

Force fit. — To fit parts, as a shaft in a gear, so that force is required to insert it.

Press fit. — Same as force fit, but to be done in a press. Pressure in tons usually being specified.

Shrink fit. — To fit parts, as a coupling on a shaft, by having the hole a little smaller than the shaft, heating the coupling until the shaft enters, when the contraction of the metal on cooling makes the shrink fit.

FORGE. — To work metals by heating and hammering.

Drop forge. — To work metals by heating and forming with dies by a blow in a forge of that name.

Press forge. — To work metals by heating and forming with dies, in a forge which operates with a slow and steady pressure.

FINISH. — To turn bore or face.

Chip. — To remove lumps or rough spots with a cold chisel and hammer.

File. — To finish (as a casting) with a file.

Draw file. — To finish with a file held in both hands across the work and moved sideways, as in hand-fitting a key.

Grind. — To finish smoothly and accurately with an abrasive.

Lap. — To polish with a soft piece of metal of that name, either flat, or round for holes, and which retains the abrasive.

Polish. — To finish to a smooth bright surface with a fine abrasive.

Rough. —When no finish is desired, as parts of a casting.

Scrape. — To finish with a scraper as in fitting babbited bearings.

Dressed (or planed). — **Sand papered; rough;** finishes for timber and wood work.

Grout. — To fill with thin mortar or cement.

Ground joint. — To finish a joint in metals by grinding the parts together with an abrasive and oil.

Harden. — To heat steel and quench suddenly, usually used as, "harden and temper."

Heat treat.— To heat and quench steel to exact temperature and time rules, to improve the structure and strength; applied to steel of specified composition.

Key Seat. — To form a recess, as in a shaft pulley or gear for a key which may be straight or tapered.

Lap. — To polish with a soft piece of metal of that name, which may be either flat, or round for holes, and which retains the abrasive.

Mill. — To remove metal by the action of a toothed wheel or bar in a milling machine.

Miter. — To join at an angle, usually 45° as a miter joint.

Mortise. — To form a recess (in timber) to receive a tongue called a tenon.

Nurl. — To corrugate or make fine teeth, as on the edge of a thumb screw or any part to be turned by hand.

Peen. — To go over a surface to expand it, with the round nose of a hammer, called a ball peen hammer.

Polish. — To finish to a smooth bright surface with a fine abrasive.

Rabbet. — To recess or groove along the edge of a timber or plank, usually to relieve the ends of other timbers or plank and make a flush joint.

Ream. — To finish a hole smoothly and accurately with a tool of that name.

Rivet. — To fasten two or more parts together with pins, called rivets.

Shrink. — See Fit.

Scarf. — To form a long joint usually in timber, and as distinguished from a butt joint.

Spot face. — To finish a round surface at the spot

designated, usually on a casting around a bolt hole for a nut seat.

Solder. — To unite two metals with soft solder consisting of tin and lead.

Sweat (joint). — To unite metals by first "tinning" them with solder, then holding the parts together and applying just enough heat to start or sweat the solder.

Stay bolt. — To fasten with bolts of that name, as parallel plates in a boiler.

Tap. — To cut a thread in a hole with a tool of that name.

Temper. — To reheat hardened steel to a predetermined temperature or "color," according to the intended use, and then quench.

Tenon. — To form a tongue of wood to fit in a recess, called a mortise.

Thread. — To form a screw thread either with a die or in a lathe.

Treenail. — To fasten with a wooden pin (Locust) the inside end of which is split and fitted with a wedge which on striking the bottom of the hole expands the pin and secures it.

Turn. — To finish in a machine which revolves the work as in a lathe, also used as "Turn Bore and Face."

Upset. — To rivet over or spread, as the end of a bolt over a nut.

Weld; Lap weld; Butt weld. — To join the edges of two pieces of metal by fusing, according to the manner in which the edges meet, whether "lapped" or "butted."

CONVENTIONAL SYMBOLS — ELECTRICAL

STANDARD SYMBOLS ADOPTED BY THE NATIONAL ELECTRICAL CONTRACTORS' ASSOCIATION AND THE AMERICAN INSTITUTE OF ARCHITECTS

Copyrighted

Ceiling Outlet; Electric only. Numeral in center indicates number of Standard 16 C.P. Incandescent Lamps.

Ceiling Outlet; Combination. $\frac{4}{2}$ indicates 4-16 C. P. Standard Incandescent Lamps and 2 Gas Burners. If gas only.

Bracket Outlet; Electric only. Numeral in center indicates number of Standard 16 C.P. Incandescent Lamps

Bracket Outlet; Combination. $\frac{4}{2}$ indicates 4-16 C.P. Standard Incandescent Lamps and 2 Gas Burners. If gas only.

Wall or Baseboard Receptacle Outlet. Numeral in center indicates number of Standard 16 C.P. Incandescent Lamps.

Floor Outlet. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.

Outlet for Outdoor Standard or Pedestal; Electric only. Numeral indicates number of Standard 16 C.P. Incandescent Lamps.

Outlet for Outdoor Standard or Pedestal; Combination. $\frac{6}{6}$ indicates 6-16 C.P. Standard Incandescent Lamps; 6 Gas Burners.

Drop Cord Outlet.

One Light Outlet, for Lamp Receptacle.

Arc Lamp Outlet.

Special Outlet, for Lighting, Heating and Power Current, as described in Specifications.

Ceiling Fan Outlet.

S^1 S. P. Switch Outlet.

S^2 D. P. Switch Outlet.

S^3 3-Way Switch Outlet.

S^4 4-Way Switch Outlet.

S^D Automatic Door Switch Outlet.

S^E Electrolier Switch Outlet.

Meter Outlet.

Show as many Symbols as there are Switches. Or in case of a very large group of Switches, indicate number of Switches by a Roman numeral, thus S′ XII; meaning 12 Single Pole Switches.

Describe Type of Switch in Specifications, that is, Flush or Surface, Push Button or Snap.

Distribution Panel.

Junction or Pull Box.

Motor Outlet; Numeral in center indicates Horse Power.

Motor Control Outlet.

Transformer

Main or Feeder run concealed under floor.

Main or Feeder run concealed under Floor above.

Main or Feeder run exposed.

Branch Circuit run concealed under Floor.

Branch Circuit run concealed under Floor above.

Branch Circuit run exposed.

Pole Line.

Riser.

Heights of Center of Wall Outlets (unless otherwise specified):	
Living Rooms	5 ft. 6 ins.
Chambers	5 ft. 0 ins.
Offices	6 ft. 0 ins.
Corridors	6 ft. 3 ins.
Height of Switches (unless otherwise specified)	4 ft. 0 ins.

Telephone Outlet; Private Service.

Telephone Outlet; Public Service.

Bell Outlet.

Buzzer Outlet.

Push Button Outlet; Numeral indicates number of Pushes.

Annunciator; Numeral indicates number of Points.

Speaking Tube.

Watchman Clock Outlet.

Watchman Station Outlet.

Master Time Clock Outlet.

Secondary Time Clock Outlet.

Door Opener.

Special Outlet; for Signal Systems, as described in Specifications.

Battery Outlet.

Circuit for Clock, Telephone, Bell or other Service, run under Floor, concealed.
Kind of Service wanted ascertained by Symbol to which line connects.

Circuit for Clock, Telephone, Bell or other Service, run under Floor above, concealed.
Kind of Service wanted ascertained by Symbol to which line connects.

Suggestions in connection with Standard Symbols for Wiring Plans:

It is important that ample space be allowed for the installation of mains, feeders, branches and distribution panels.

It is desirable that a key to the symbols used accompany all plans.

If mains, feeders, branches and distribution panels are shown on the plans, it is desirable that they be designated by letters or numbers.

CONVENTIONAL SYMBOLS

Lines — It is considered that the three most important lines of a drawing are construction lines, center lines, and dimension lines. For this reason a difference is made in their construction rather than in their weight or width. This seems a logical distinction to make and one calculated to avoid confusion.

The lines of a drawing may be broadly divided into two general classes, namely, "Lines of Construction" and "Lines of Explanation," as noted in the following groups:

Lines of Construction

General Construction Line

Heavy Construction Line

Invisible Part

Adjacent Part

Lines of Explanation

Center Lines and Pitch Lines

Extension Lines for Dimensions

Dimension Lines

Lines Showing Paths of Moving Parts

" " Section Cuts

Cross-section Lines to Indicate Material. *See Cross-sections*

PATENT OFFICE PRACTICE

The following Patent Office Symbols and rules to be observed in making drawings, on which patent applications are to be filed, have been reproduced from "Rules of Practice in the United States Patent Office" — copy of which should be consulted for full directions relating to applications for patents, and to drawings.

"THE DRAWINGS

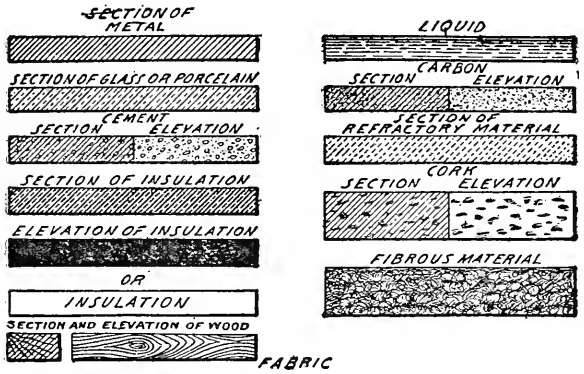
"49. The applicant for a patent is required by law to furnish a drawing of his invention whenever the nature of the case admits of it.

"50. The drawing may be signed by the inventor or one of the persons indicated in Rule 25, or the name of the applicant may be signed on the drawing by his attorney in fact. The drawing must show every feature of the invention covered by the claims, and the figures should be consecutively numbered, if possible. When the invention consists of an improvement on an old machine the drawing must exhibit, in one or more views, the invention itself, disconnected from the old structure, and also in another view, so much only of the old structure as will suffice to show the connection of the invention therewith.

"51. Two editions of patent drawings are printed and published — one for office use, certified copies, etc., of the size and character of those attached to patents, the work being about 6 by $9\frac{1}{2}$ inches; and one reduction

CHART FOR DRAFTSMEN.

SECTIONS



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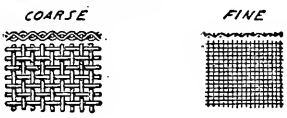

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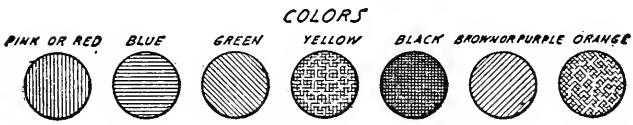

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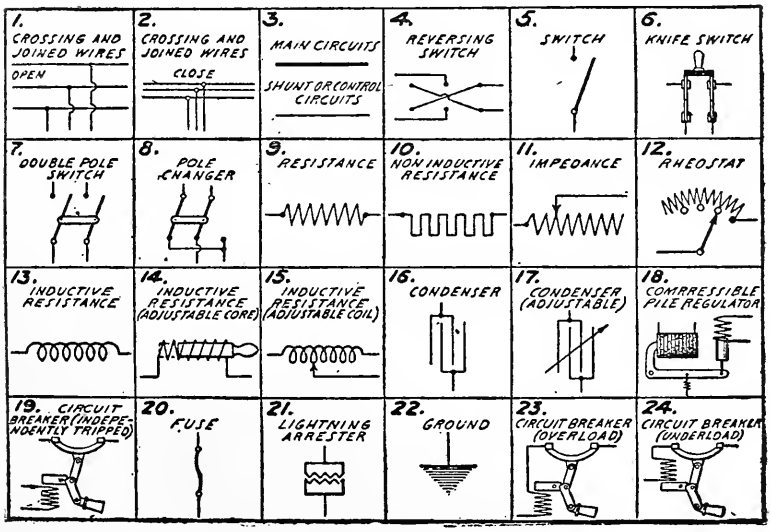
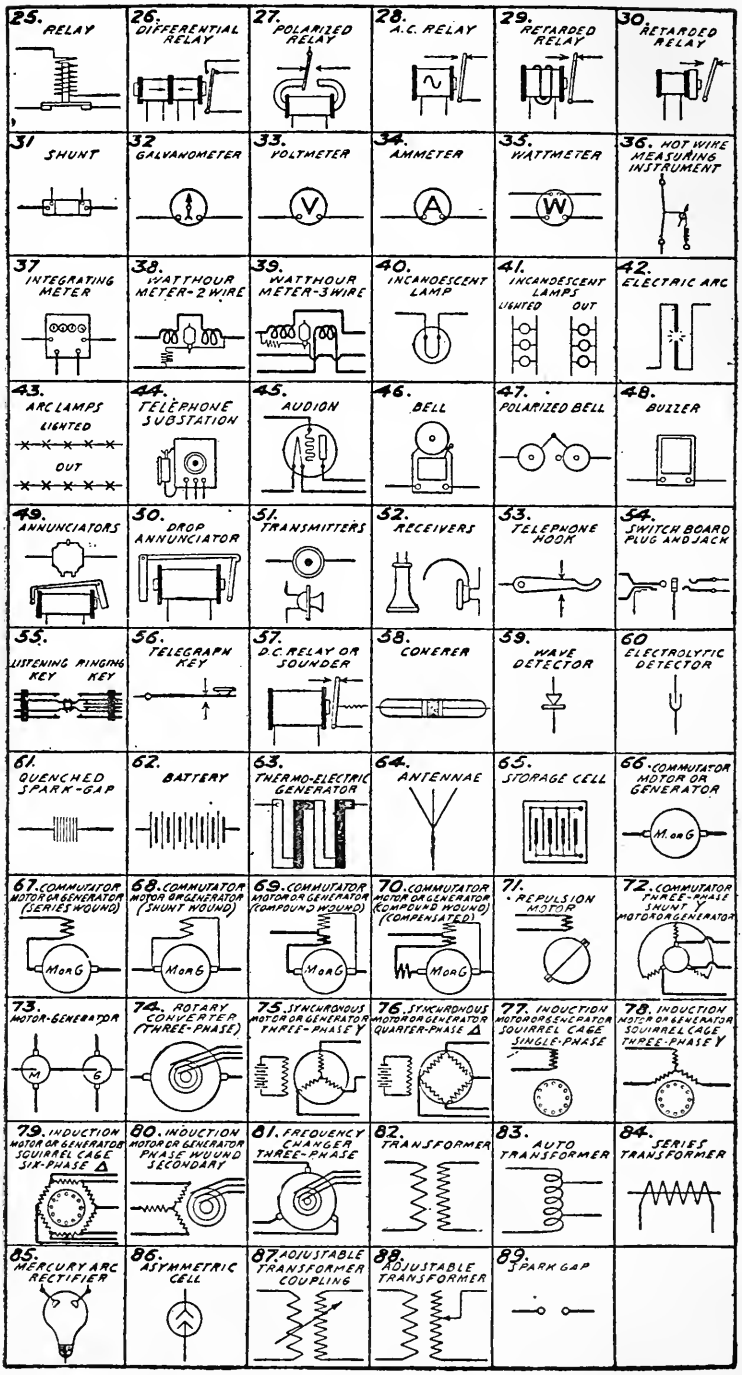
ELECTRICAL SYMBOLS.



ELECTRICAL SYMBOLS.



of a selected portion of each drawing for the Official Gazette.

"52. This work is done by the photolithographic process, and therefore the character of each original drawing must be brought as nearly as possible to a uniform standard of excellence, suited to the requirements of the process, to give the best results, in the interests of inventors, of the office, and of the public. The following rules will therefore be rigidly enforced, and any departure from them will be certain to cause delay in the examination of an application for letters patent:

"(*a*) Drawings must be made upon pure white paper of a thickness corresponding to two-sheet or three-sheet Bristol board. The surface of the paper must be calendered and smooth. India ink alone must be used, to secure perfectly black and solid lines.

"(*b*) The size of a sheet on which a drawing is made must be exactly 10 by 15 inches. One inch from its edges a single marginal line is to be drawn, leaving the "sight" precisely 8 by 13 inches. Within this margin all work and signatures must be included. One of the shorter sides of the sheet is regarded as its top, and, measuring downwardly from the marginal line, a space of not less than $1\frac{1}{4}$ inches is to be left blank for the heading of title, name, number, and date.

"(*c*) All drawings must be made with the pen only. Every line and letter (signatures included) must be absolutely black. This direction applies to all lines, however fine, to shading, and to lines representing cut surfaces in sectional views. All lines must be clean, sharp, and solid, and they must not be too fine or crowded. Surface shading, when used, should be open. Sectional shading should be made by oblique parallel lines, which

may be about one-twentieth of an inch apart. Solid black should not be used for sectional or surface shading. Free-hand work should be avoided wherever it is possible to do so.

"(*d*) Drawings should be made with the fewest lines possible consistent with clearness. By the observance of this rule the effectiveness of the work after reduction will be much increased. Shading (except on sectional views) should be used only on convex and concave surfaces, where it should be used sparingly, and may even there be dispensed with if the drawing be otherwise well executed. The plane upon which a sectional view is taken should be indicated on the general view by a broken or dotted line, which should be designated by numerals corresponding to the number of the sectional view. Heavy lines on the shade sides of objects should be used, except where they tend to thicken the work and obscure letters of reference. The light is always supposed to come from the upper left-hand corner at an angle of 45°.

"(*e*) The scale to which a drawing is made ought to be large enough to show the mechanism without crowding, and two or more sheets should be used if one does not give sufficient room to accomplish this end; but the number of sheets must never be more than is absolutely necessary.

"(*f*) The different views should be consecutively numbered. Letters and figures of reference must be carefully formed. They should, if possible, measure at least one-eighth of an inch in height, so that they may bear reduction to one twenty-fourth of an inch; and they may be much larger when there is sufficient room. They must be so placed in the close and complex parts of drawings as not to interfere with a thorough comprehension of the

same, and therefore should rarely cross or mingle with the lines. When necessarily grouped around a certain part they should be placed at a little distance, where there is available space, and connected by lines with the parts to which they refer. They should not be placed upon shaded surfaces, but when it is difficult to avoid this, a blank space must be left in the shading where the letter occurs, so that it shall appear perfectly distinct and separate from the work. If the same part of an invention appear in more than one view of the drawing it must always be represented by the same character, and the same character must never be used to designate different parts.

"(*g*) The signature of the applicant should be placed at the lower right-hand corner of each sheet, and the signatures of the witnesses, if any, at the lower left-hand corner, all within the marginal line, but in no instance should they trespass upon the drawings. (See specimen drawing, appendix.) The title should be written with pencil on the back of the sheet. The permanent names and title constituting the heading will be applied subsequently by the office in uniform style.

"(*h*) All views on the same sheet must stand in the same direction and must if possible stand so that they can be read with the sheet held in an upright position. If views longer than the width of the sheet are necessary for the proper illustration of the invention the sheet may be turned on its side. The space for heading must then be reserved at the right and the signatures placed at the left, occupying the same space and position as in the upright views and being horizontal when the sheet is held in an upright position. One figure must not be placed upon another or within the outline of another.

"(*i*) As a rule, one view only of each invention can be shown in the Gazette illustrations. The selection of that portion of a drawing best calculated to explain the nature of the specific improvement would be facilitated and the final result improved by the judicious execution of a figure with express reference to the Gazette, but which must at the same time serve as one of the figures referred to in the specification. For this purpose the figure may be a plan, elevation, section, or perspective view, according to the judgment of the draftsman. All its parts should be especially open and distinct, with very little or no shading, and it must illustrate the invention claimed only, to the exclusion of all other details. (See specimen drawing.) When well executed, it will be used without curtailment or change, but any excessive fineness, or crowding, or unnecessary elaborateness of detail, will necessitate its exclusion from the Gazette.

"(*j*) Drawings transmitted to the office should be sent flat, protected by a sheet of heavy binder's board; or should be rolled for transmission in a suitable mailing tube, but should never be folded.

"(*k*) An agent's or attorney's stamp, or advertisement, or written address will not be permitted upon the face of a drawing, within or without the marginal line.

"53. All reissue applications must be accompanied by new drawings, of the character required in original applications, and the inventor's name must appear upon the same in all cases; and such drawings shall be made upon the same scale as the original drawing, or upon a larger scale, unless a reduction of scale shall be authorized by the Commissioner.

"54. The foregoing rules relating to drawings will be rigidly enforced. A drawing not executed in conformity

thereto may be admitted for purposes of examination if it sufficiently illustrate the invention, but in such case the drawing must be corrected or a new one furnished before the application will be allowed. The necessary corrections will be made by the office, upon applicant's request and at his expense. (See Rule 72.)

"55. Applicants are advised to employ competent draftsmen to make their drawings.

"The office will furnish the drawings at cost, as promptly as its draftsmen can make them, for applicants who can not otherwise conveniently procure them.

THE MODEL

"56. A model will be required or admitted as a part of the application only when on examination of the case in its regular order the primary examiner shall find it to be necessary or useful. In such case, if a model has not been furnished, the examiner shall notify the applicant of such requirement, which will constitute an official action in the case. When a model has been received in compliance with the official requirement, the date of its filing shall be entered on the file wrapper. Models not required nor admitted will be returned to the applicants. When a model is required, the examination may be suspended until it shall have been filed.

"57. The model must clearly exhibit every feature of the machine which forms the subject of a claim of invention, but should not include other matter than that covered by the actual invention or improvement, unless it be necessary to the exhibition of the invention in a working model.

"58. The model must be neatly and substantially made of durable material, metal being deemed prefera-

ble; but when the material forms an essential feature of the invention, the model should be constructed of that material.

"59. A working model may be required if necessary to enable the office fully and readily to understand the precise operation of the machine.

"60. In all applications which have become abandoned, the model, unless it be deemed necessary that it be preserved in the office, may be returned to the applicant upon demand and at his expense; and the model in any pending case of less than one year's standing may be returned to the applicant upon the filing of a formal abandonment of the application, signed by the applicant in person and any assignee. (See Rule 171.)

"Models belonging to patented cases shall not be taken from the office except in the custody of some sworn employee of the office specially authorized by the Commissioner.

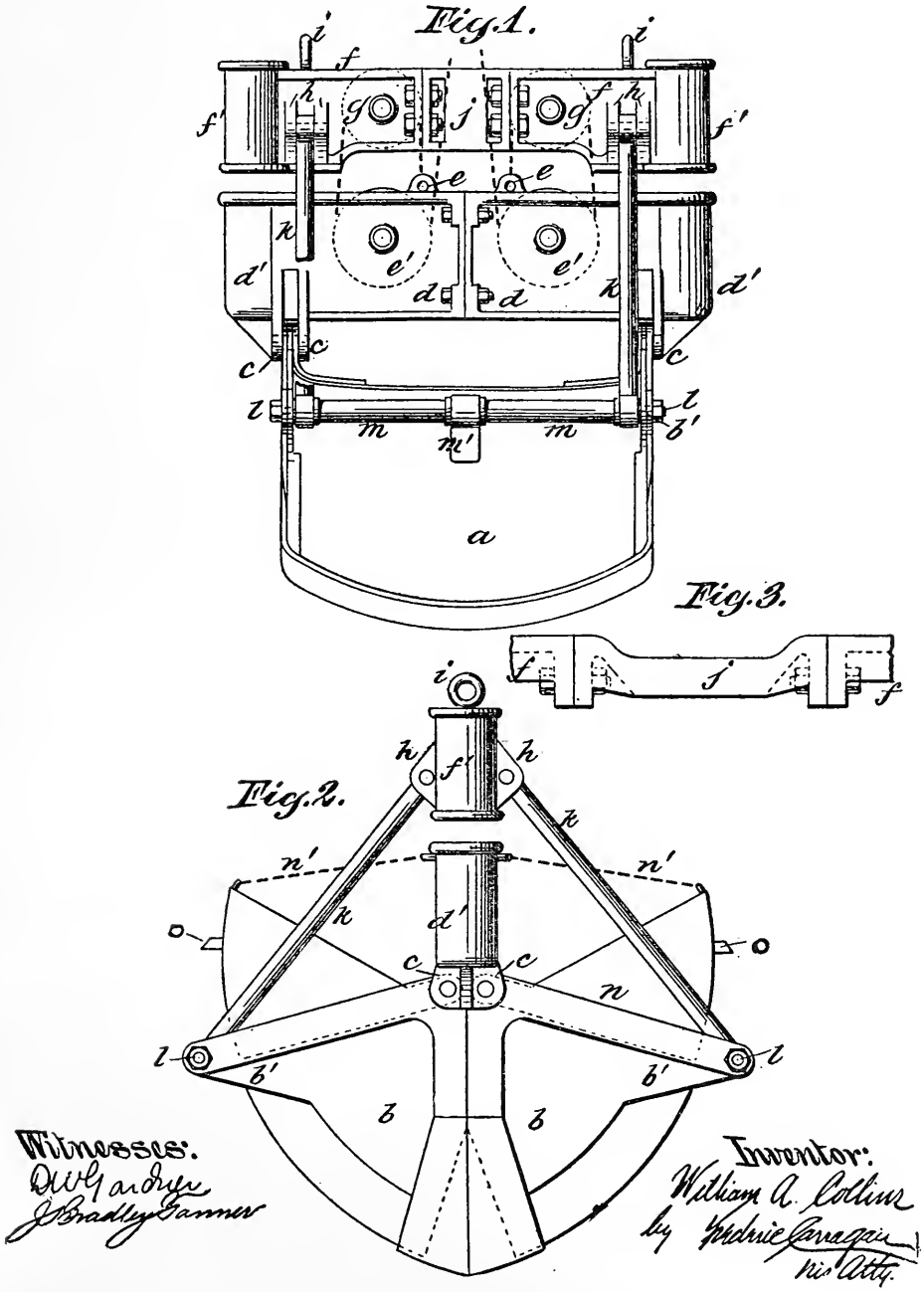
"61. Models filed as exhibits in contested cases may be returned to the parties at their expense. If not claimed within a reasonable time, they may be disposed of at the discretion of the Commissioner."

(No Model.) 2 Sheets—Sheet 1.

W. A. COLLINS.

DREDGING BUCKET.

No. 572,651. Patented Dec. 8, 1896.



Typical Patent Office Drawing

(No Model.) 2 Sheets—Sheet 2.

W. A. COLLINS.

DREDGING BUCKET.

No. 572,651. Patented Dec. 8, 1896.

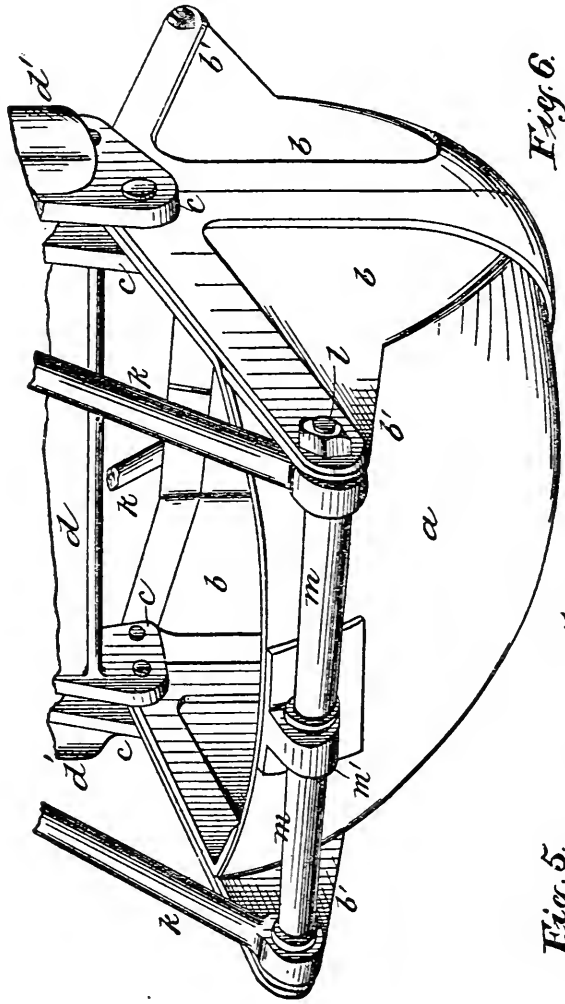


Fig. 4.

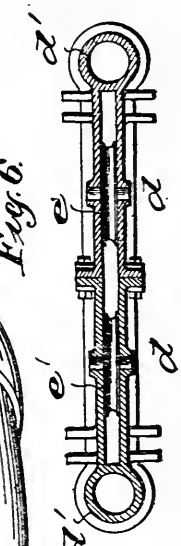


Fig. 6.

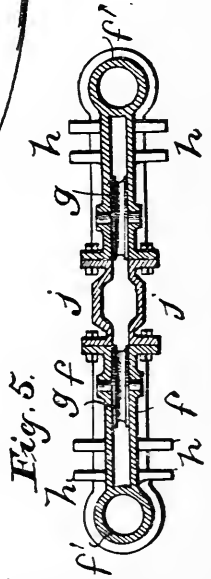


Fig. 5.

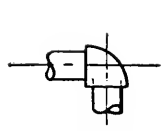
Witnesses:
D. W. Gardner
J. Bradley Tanner

Inventor:
William A. Collins
by Frederic Cavagnaro
his Atty.

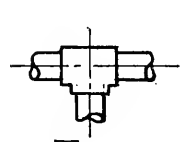
Typical Patent Office Drawing

CONVENTIONAL SYMBOLS

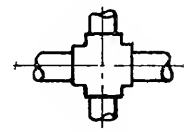
PIPE FITTINGS



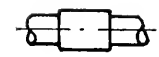
Elbow



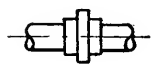
Tee



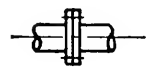
Cross

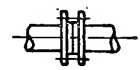


Coupling

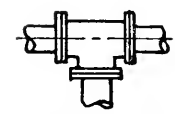


Union

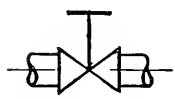




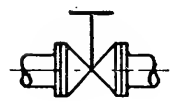
Flanged Unions



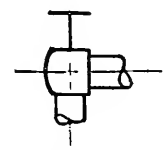
Flanged Tee



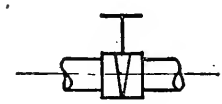
Screw Valve



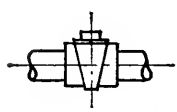
Flanged Valve



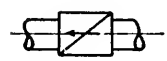
Angle Valve



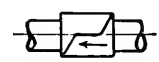
Gate Valve



Plug Cock

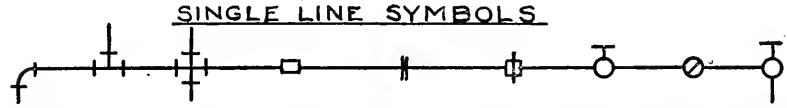


Swing Check Valve



Lift Check Valve

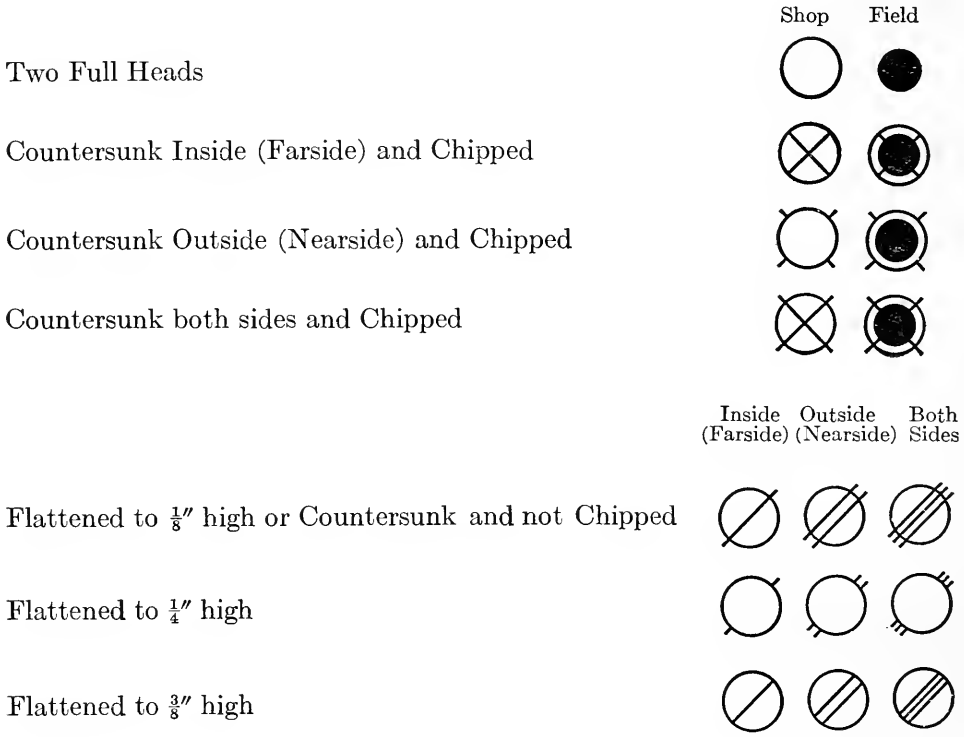
SINGLE LINE SYMBOLS



Elbow Tee Cross Coup- ling. Flange Union Screw Union Globe Valve Check Valve Angle Valve

CONVENTIONAL SIGNS FOR RIVETING

Reproduced by permission from "Cambria."



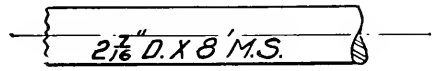
This system, designed by F. C. Osborn, C. E., has for foundation the diagonal cross to represent a countersink, the blackened circle for a field rivet, and the diagonal stroke to indicate a flattened head. The position of the cross, with respect to the circle (inside, outside, or both sides), indicates the location of the countersink and, similarly, the number and position of the diagonal strokes indicate the height and position of the flattened heads.

Any combination of field, countersunk and flattened head rivets liable to occur may be readily indicated by the proper combination of above signs.

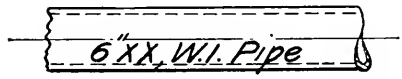
CONVENTIONAL SYMBOLS — BREAKS

STRUCTURAL MATERIAL

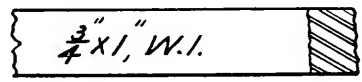
Round bar of metal. Section end according to material as given under cross-sections.



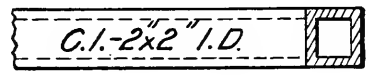
Tube or pipe. Section end as above.



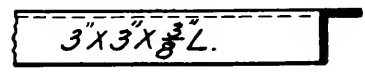
Rectangular bar of metal. Section end as above.



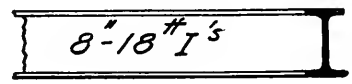
Hollow metal pipe or duct. Section end as above.



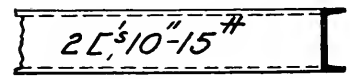
Breaks in rolled shapes usually shown by blacking ends in solid.



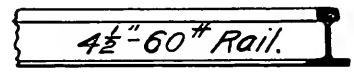
When number of pieces are not called for — mark this way.



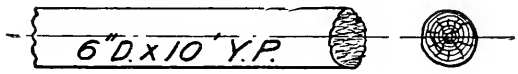
When number of pieces are called for, mark this way.



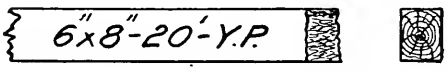
Rail — New or Relayers.



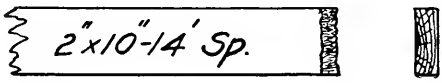
Round Timber.



Square Timber.



Plank.

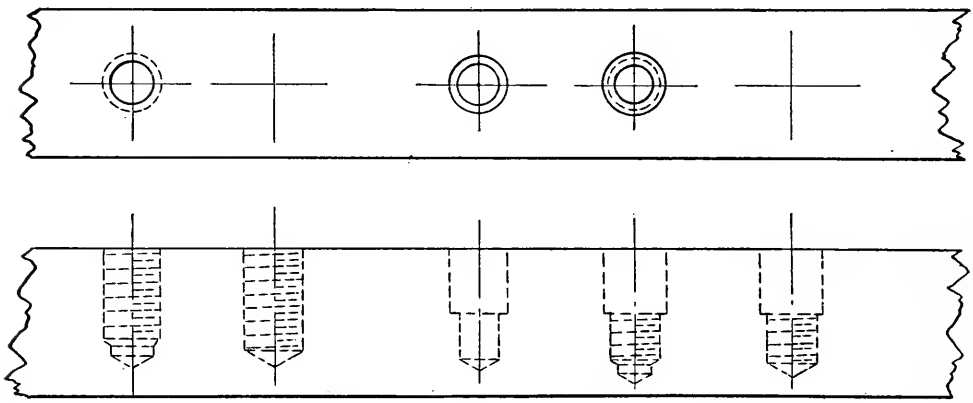


Timber — Usually rough or standing.
Lumber — Sawn or worked timber.
Kind — Round, square, plank, etc.
Finishes — R. = Rough Dr. = Dressed
S4S = Surfaced 4 Sides.
S2S & 1 E = Surfaced 2 Sides and 1 edge, etc.

THREADS AND TAPPED HOLES

Threads and Tapped Holes. — For dimensions of all kinds of bolts, screws, etc., and much valuable tool and shop information which should be in the hands of every draftsman, reference should be made to the handbooks.

There is some difference noted in showing tapped holes, and similarity in showing counterbored and tapped holes. The following examples will at least make a distinction there.



TOPOGRAPHIC SYMBOLS

The following symbols are used by the U. S. Geological Survey and, with the explanatory text, have been reproduced from a typical U. S. topographic map.

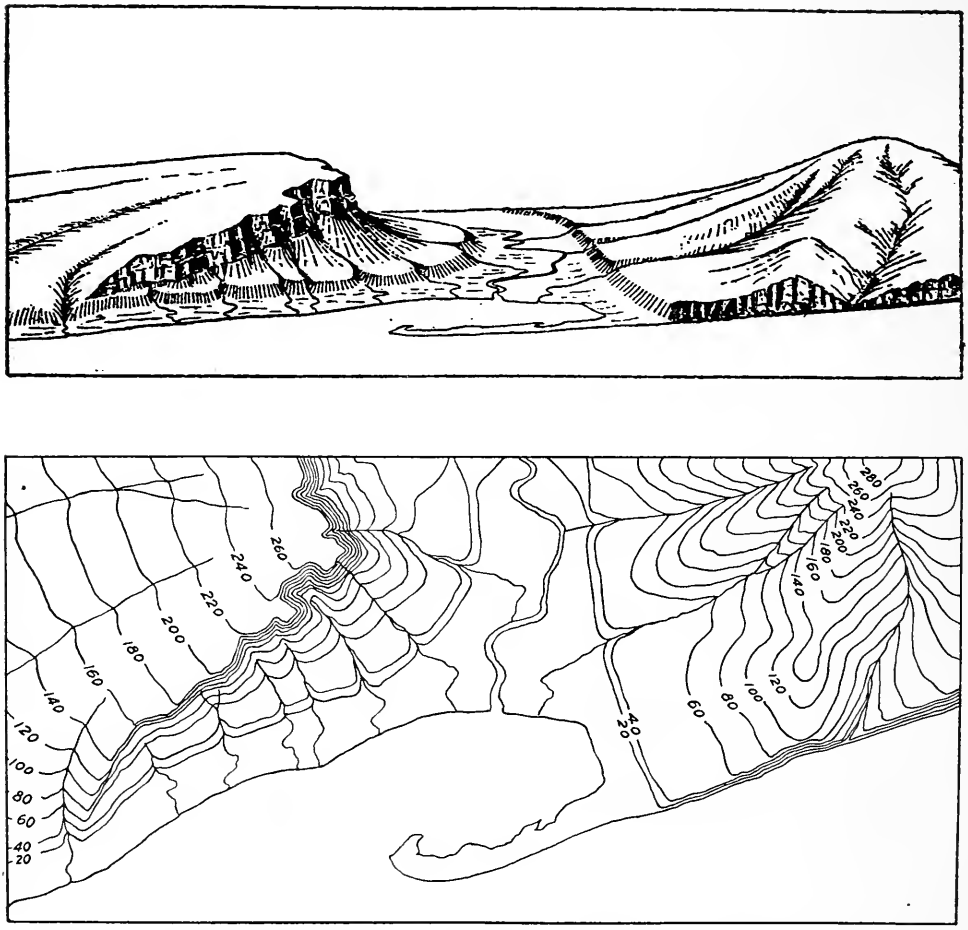
The features shown on these atlas sheets or maps may be classed in three groups — (1) *water*, including seas, lakes, rivers, canals, swamps, and other bodies of water; (2) *relief*, including mountains, hills, valleys, and other elevations and depressions; (3) *culture* (works of man), such as towns, cities, roads, railroads, and boundaries. The conventional signs used for these features are shown below, with explanations.

All water features are printed in *blue*, the smaller streams and canals in full blue lines and the larger streams, lakes, and the sea in blue water-lining. Intermittent streams — those whose beds are dry at least three months in the year — are shown by lines of dots and dashes.

Relief is shown by contour lines in *brown*. A contour on the ground passes through points that have the same altitude. One who follows a contour will go neither uphill nor downhill but on a level. The contour lines on the map show not only the shapes of the hills, mountains, and valleys but also their elevations. The line of the seacoast itself is a contour line, the datum or zero of elevation being mean sea level. The contour at, say, twenty feet above sea level would be the shore line if the sea were to rise or the land to sink twenty feet. On a gentle slope this contour is far from the present coast; on a steep slope it is near the coast. Where successive

contour lines are far apart on the map they indicate a gentle slope; where they are close together they indicate a steep slope; and where they run together in one line they indicate a cliff.

The manner in which contour lines express altitude, form, and grade is shown in the figure below.

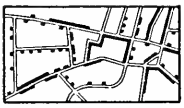


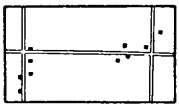
The sketch represents a river valley between two hills. In the foreground is the sea, with a bay that is partly inclosed by a hooked sand bar. On each side of the valley is a terrace into which small streams have cut narrow gullies. The hill on the right has a rounded summit and gently sloping spurs separated by ravines. The

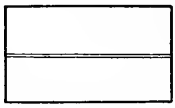
spurs are truncated at their lower ends by a sea cliff. The hill on the left terminates abruptly at the valley in a steep scarp. It slopes gradually back away from the scarp and forms an inclined table-land, which is traversed by a few shallow gullies. On the map each of these features is indicated, directly beneath its position in the sketch, by contour lines.

The works of man are shown in *black*, in which color all lettering also is printed. Boundaries, such as those of a State, county, city, land grant, township, or reservation, are shown by continuous or broken lines of different kinds and weights. Public and through roads are shown by fine double lines; private and poor roads by dashed double lines; trails by dashed single lines.

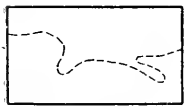
CULTURE
(Printed in Black)

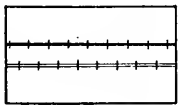

City or Village

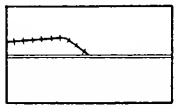

Roads and Buildings

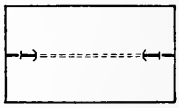

Metaled Road
(distinguished on recent maps only)

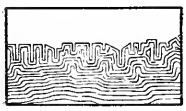
Private or Secondary Road

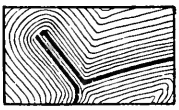

Trail or Path

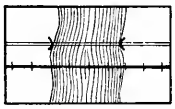

Railroads

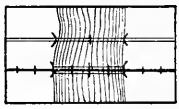

Electric Railroad

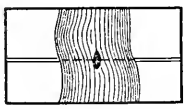

Tunnel

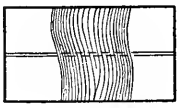

Wharves

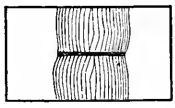

Breakwater and Jetties

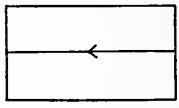

Bridges

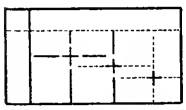

Drawbridges

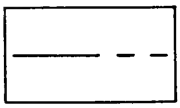

Ferry
(Point Upstream)

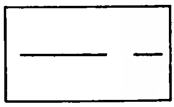

Ford


Dam

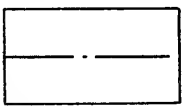

Canal Lock
(Point up Stream)

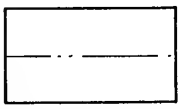

U.S. Township and Section Lines and located Corners


State Line


County Line

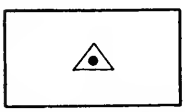
Civil Township or District Line


Reservation Line

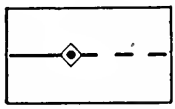

Land Grant Line

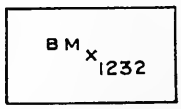
City Village or Borough Line

Small Park or Cemetery Line


Triangulation or Primary Traverse Monument

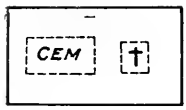
U.S. Mineral Monument


Boundary Monument

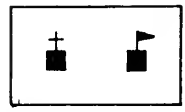


Bench Mark
(Temporary bench mark shown by brown cross and black figures without lettering)

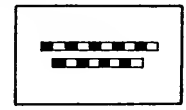
CULTURE
(Continued)



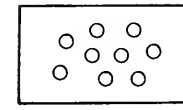
Cemeteries



Church, School
(Distinguished on recent Maps)

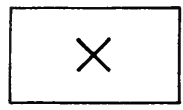


Coke Ovens



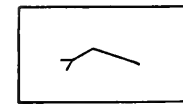
Oil Wells

Mine or Quarry



Prospect

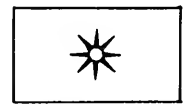
Shaft



Mine Tunnel
(Showing Direction)

Mine Tunnel
(Direction Unknown)

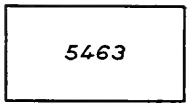
Light-Ship



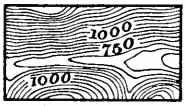
Lighthouse or Beacon

Life-Saving Station

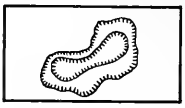
RELIEF
(Printed in Brown)



Figures
(Showing heights above mean sea level instrumentally determined)

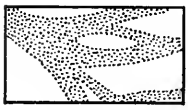


Contours
(Showing height above sea, horizontal form, and steepness of slope of the surface)



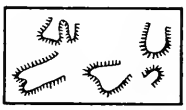
Depression Contours

Levee

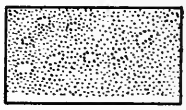


Wash

Cliffs

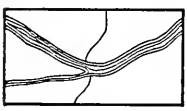


Mine Dumps

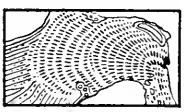


Sand and Sand Dunes

WATER
(Printed in Blue)

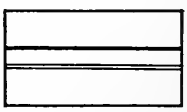


Streams

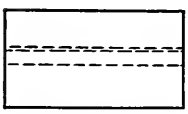


Falls and Rapids

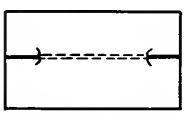
Intermittent Streams and Ditches



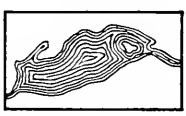
Canals or Ditches



Aqueducts or Waterpipes

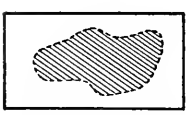


Aqueduct Tunnel



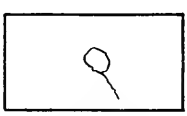
Lake or Pond

Unsurveyed Streams and abandoned Canals

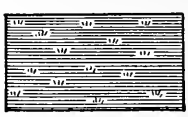


Intermittent Lake

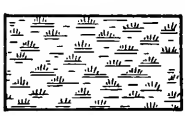
Glacier
(Or shown by contours printed in Blue)



Spring



Salt Marsh



Fresh Marsh

Grassy Pond

Tidal Flat

WOODS
(When shown, printed in Green)

PART III

FORMS

FORM SIZES
DRAWING SIZES
APPLICATION BLANK
ARRANGEMENT OF DRAWING
BUILDING AND EQUIPMENT RECORD
PRINT RECORD
PATTERN RECORD
INDEX CARDS
MATERIAL LIST
SPECIFICATIONS
ORGANIZATION CHART
RUBBER STAMPS
TITLES
WORK SCHEDULE
WORK ORDERS

FORM SIZES

Forms should be made on $8\frac{1}{2}'' \times 11''$ sheets, or fractions or multiples of this size, as:

$4\frac{1}{4}'' \times 5\frac{1}{2}''$
$5\frac{1}{2}'' \times 8\frac{1}{2}''$
$8\frac{1}{2}'' \times 11''$
$11\ '' \times 17''$
$17\ '' \times 22''$

Each form should have a number assigned to it for record in a form record book. This book is preferably $8\frac{1}{2}'' \times 11''$ size and a sample of each form should be pasted in it and records of numbers printed and printing costs kept.

It is advisable to have all new forms first made on typewriter and copies multigraphed for trial if size permits. Changes can then be made before final printing. An example is the application blank following. If the form is too large for this method, then a tracing can be made and Van Dyke prints, which give blue lines on a white ground, made from that for trial.

DRAWING SIZES

MARK	OVER ALL		MARGIN	TITLE	SQ.FT.
	HIGHT	LENGTH			
A	$8\frac{1}{2}$	11	$\frac{1}{4}$	$1\frac{5}{8} \times 4$	$\frac{2}{3}$
B	12	18	$\frac{1}{4}$	$2\frac{1}{8} \times 4\frac{1}{2}$	$1\frac{1}{2}$
C	18	24	$\frac{3}{8}$	$2\frac{1}{8} \times 4\frac{1}{2}$	3
D	24	36	$\frac{3}{8}$	$2\frac{1}{8} \times 4\frac{1}{2}$	6
E	30	41	$\frac{3}{8}$	$2\frac{1}{8} \times 4\frac{1}{2}$	$8\frac{3}{4}$

APPLICATION

Name of company.....Department.....

Number.....Date.....Position applied for.....

Name.....Address.....

Schools or colleges attended.	From	To	Courses	Degrees

Languages spoken.....Written.....

RECORD OF FORMER AND PRESENT EMPLOYMENT — LAST FOUR POSITIONS

	From Month	From Year	To Month	To Year	Name of Employer	Head of Dep't.	Address
1							
2							
3							
4							

(Give kind of work done in each position on back of this sheet.)

Can we refer to all?.....If not, indicate three.....

Reason for leaving last position.....

When available.....

Salary expected.....Last salary received.....

Date of birth.....Place of birth.....

Height.....Weight.....Married.....

Are you a citizen of the United States?.....

Ever employed by this company?.....If so, when?.....

Describe any special experience or training that you have had.....

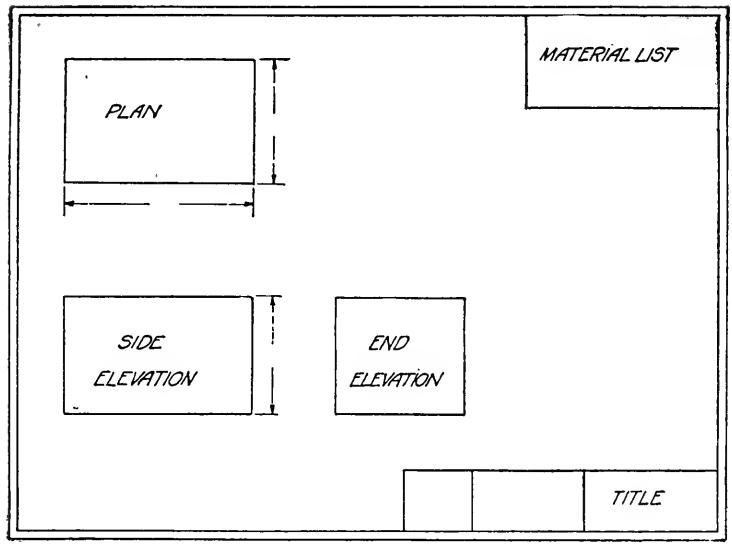
.....

.....

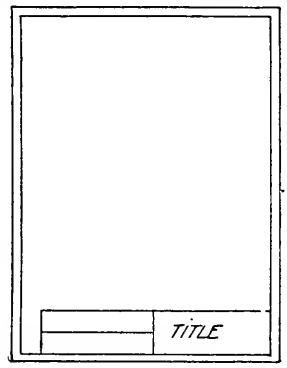
.....

Engaged.....Date.....Rate.....Filed.....Rejected.....

TYPICAL ARRANGEMENT OF VIEWS, TITLE AND MATERIAL LIST FOR ALL SHEETS EXCEPT 'A':



TYPICAL ARRANGEMENT OF 'A' SHEET.



BUILDING AND EQUIPMENT RECORD

(Name of company)

Plant.....Date.....

Section.....Product.....

Building No.....Size.....Stories.....

Type Roof.....

Construction Materials.....

Kind of Foundation.....

CONNECTIONS

Comp. Air	Electric	Gas	Sewer	Steam	Water	
.....	.....	.....	.....	.....	.....	.....

Railroad station.....Distance.....

Telephone exchange.....Number.....

EQUIPMENT

Name	No. in use	Maker's no.	Kind	Size	Type
.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	.....	.....

Remarks.....

.....

.....

Compiled.....Checked.....Approved.....

DRAWING RECORD (Left hand Page)

Nº	DATE	PLANT	PART	DESCRIPTION	DR. BY	REMARKS

PRINT RECORD (Right hand Page)

Nº	TO	DATE	Nº	TO	DATE	Nº	TO	DATE	Nº	TO	DATE	Nº	TO	DATE	Nº	TO	DATE

PATTERN RECORD (Left hand Page)

OUR Nº	OTHERS Nº	NAME			MADE BY	DATE	COST	
		PLANT	PART	DESCRIPTION				

PATTERN RECORD (Right hand Page)

TO		TO		TO		TO		TO	
NAME	DATE	NAME	DATE	NAME	DATE	NAME	DATE	NAME	DATE

DRAWING AND PATTERN RECORD BOOKS

INDEX CARDS

(Index letter) (Section of file)

PLANT	PART	DESCRIPTION	DWG. NO.		

(Index letter) (By Articles or Manufacturers)

NAME	ARTICLE	NO.

PRINT ORDER _____ (Date) _____ 19__

HOW MANY	DWG. NO.	REQUIRED BY	FOR	RECEIVED BY

MATERIAL LIST

form A 93.

Name of Company
Address or Dept

ORDER Nº _____ PLANT _____

PROJECT _____ PART _____

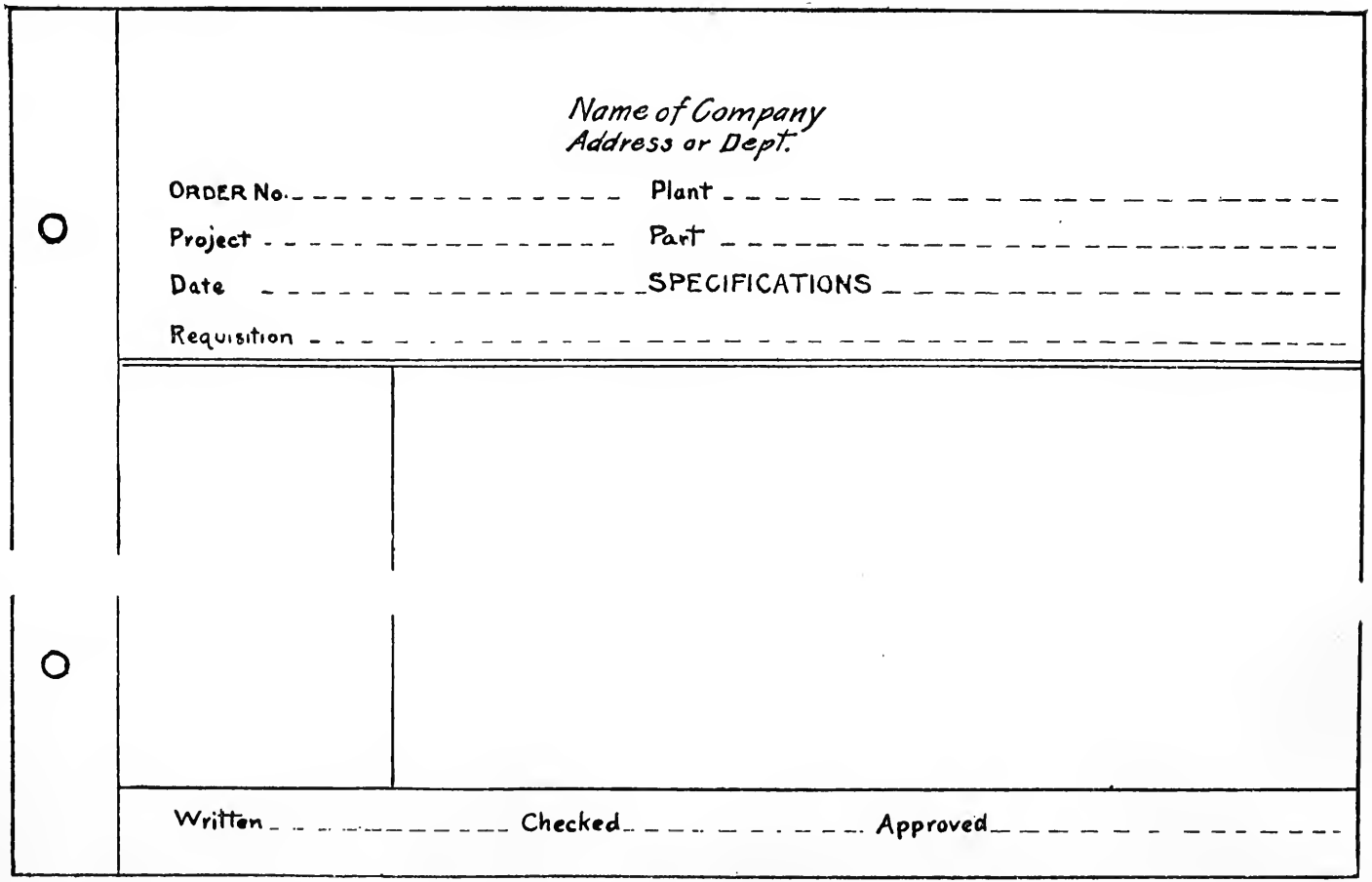
DATE _____ MATERIAL _____ *(Kind or Misc.)* _____

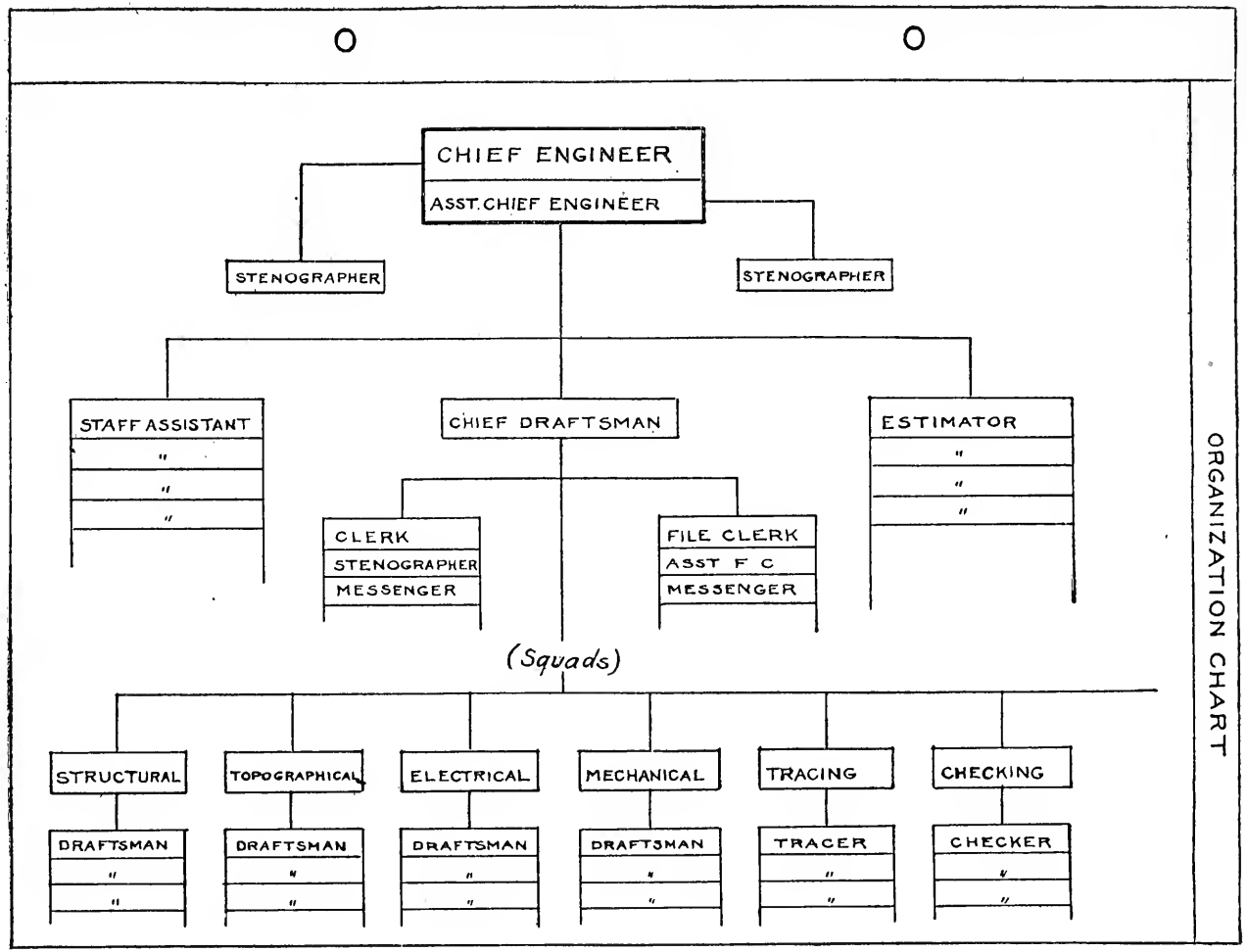
REQUISITION _____

PART Nº	Dwg. No	PART OR MEMBER	No. Pcs	DESCRIPTION	TOTAL

COMPILED _____ CHECKED _____ APPROVED _____

SPECIFICATIONS




ORGANIZATION CHART
CHIEF ENGINEER
ASST. CHIEF ENGINEER
STENOGRAPHER
STENOGRAPHER
STAFF ASSISTANT
"
"
"
CHIEF DRAFTSMAN
ESTIMATOR
"
"
"
CLERK
STENOGRAPHER
MESSENGER
FILE CLERK
ASST F C
MESSENGER
(Squads)
STRUCTURAL
TOPOGRAPHICAL
ELECTRICAL
MECHANICAL
TRACING
CHECKING
DRAFTSMAN
"
"
DRAFTSMAN
"
"
DRAFTSMAN
"
"
DRAFTSMAN
"
"
TRACER
"
"
CHECKER
"
"

RUBBER STAMP FORMS

Scale Half Size

Filing Department stamp for foreign prints.

(Company Name)
ENGINEERING DEPARTMENT, --(Place)--
RECEIVED....(Date).....
DRAFTING ROOM FILE Nº.....

Stamp for prints sent out before approval.

PRELIMINARY PRINT

Stamp for the first print from all tracings including revisions.

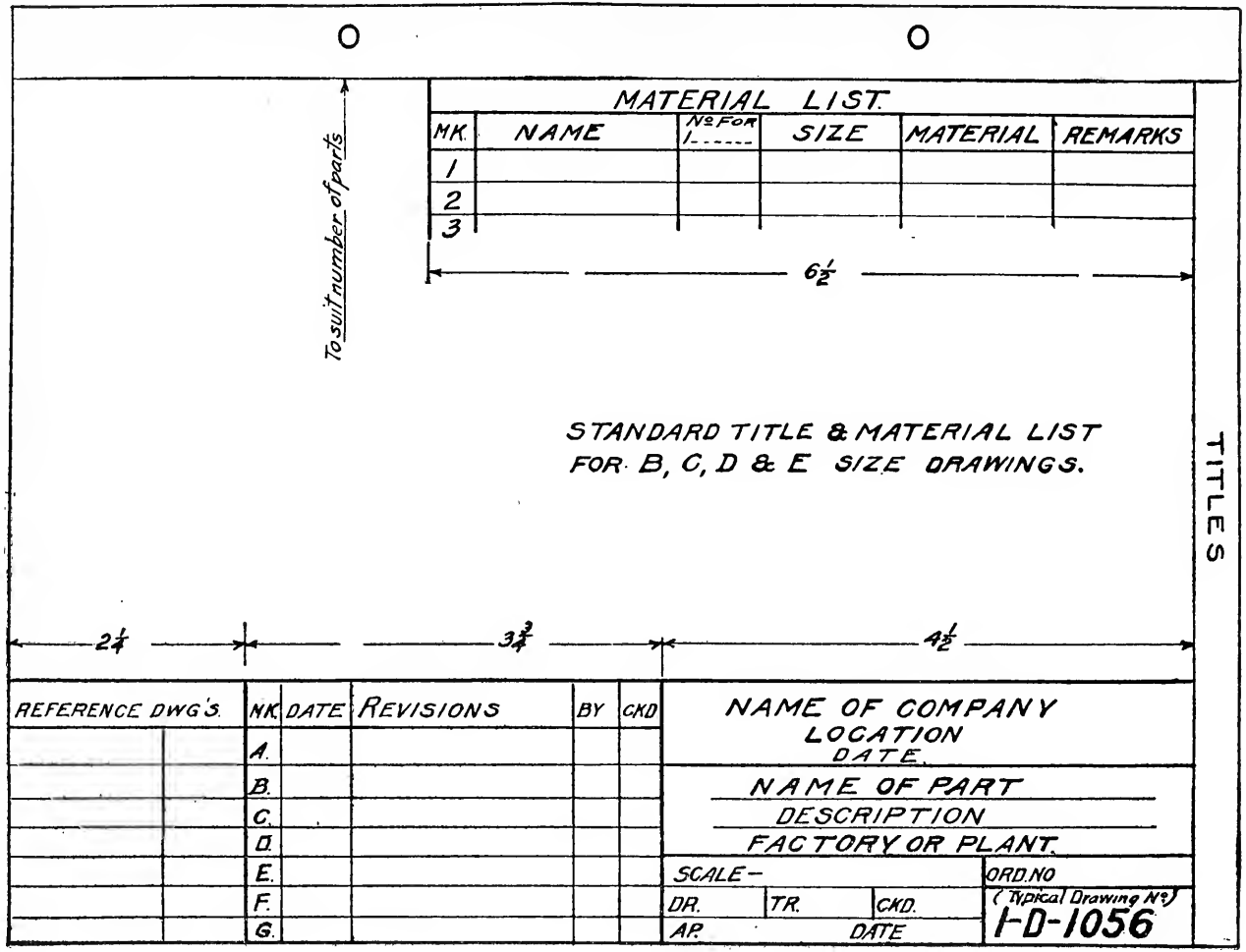
RECORD PRINT
(Date)
Not to be taken from Eng. Dept.

Stamp for void drawings, giving name of person authorizing cancellation, and the superseding drawing Nº

VOID (Date) 19....BY. (Authority)....
SUPERSEDED BY ..(Drawing Nº.).....

Stamp for calling attention to a Revised Print.

REVISED PRINT
Date
DESTROY EARLIER REVISIONS


MATERIAL LIST
MK.
NAME
No. FOR 1
SIZE
MATERIAL
REMARKS
1
2
3
6½
To suit number of parts
STANDARD TITLE & MATERIAL LIST
FOR B, C, D & E SIZE DRAWINGS.
TITLES
2¼
3¾
4½
REFERENCE DWG'S.
MK.
DATE
REVISIONS
BY
CKD
A.
B.
C.
D.
E.
F.
G.
NAME OF COMPANY
LOCATION
DATE.
NAME OF PART
DESCRIPTION
FACTORY OR PLANT.
SCALE –
ORD. NO
DR.
TR.
CKD.
AP.
DATE
(Typical Drawing No.)
I-D-1056

Form A-100

(class of work or squad) DRAFTING ROOM SCHEDULE ---------- 19--

ORDER NO.	NAME	PLANT	DESCRIPTION	COMMENCED BY	COMMENCED DATE	TO BE COMPLETED	DRAWING NO.	REMARKS

SCHEDULE

WORK ORDER FORM

Name of Company

ENGINEERING DIVISION—WORK AUTHORIZATION

Name _____

Plant _____ Location _____

Character of Work. _____

Authorized by _____ Date _____

Appropriation Approved _____ Charge No. _____

DIRECTIONS.

Front side of first and second sheets. First sheets on distinctive paper and printed on both sides. Reverse side for draftsmans time record. Second sheets on thin white paper suitable for manifolding; size 8½" x 11."

Further information to be supplied by _____ To complete _____

Commenced by _____ Date _____ Completed _____

SIGNED _____ DATE _____ No. _____

WORK ORDER FORM. *(Reverse side)*

TITLES MUST APPEAR ON DRAWINGS AS HERE GIVEN

TITLE	Dwg No.	Notes

IF ADDITIONAL SPACE IS REQUIRED FOR DWG NOS. ETC. USE TWO SHEETS.

DRAFTSMAN'S TIME RECORD

UNDER KIND, INSERT KIND OF WORK AS DES., DWG., TRC., CKG., REV.

DATE	KIND	BY	COMMENCED		COMPLETED		TOTAL		REMARKS
			DATE	TIME	DATE	TIME	HRS	MIN	

RETURN THIS SHEET, PROPERLY FILLED OUT, WITH COMPLETED WORK.

PART IV

MISCELLANEOUS TABLES

BOLT STRESSES
BOLTS AND NUTS
BOLT THREADS
WASHERS
WEIGHT — STEEL BARS
STUDS
PIPE THREAD — BRIGGS
PIPE SIZES
BOILER TUBES
PIPE FLANGES
PIPE FITTINGS
KEY-WAYS
SHAFTING H.P.
GAGES — SHEET
GAGES — WIRE
METRIC CONVERSION
WEIGHTS AND MEASURES
DECIMAL EQUIVALENTS
AREAS AND CIRCUMFERENCES OF CIRCLES
REFERENCE BOOKS

STRESSES IN BOLTS

Tensile Stress at 10,000 lbs. per sq. in. at **Root of "U.S." Thread.**
Shearing Stress at 8000 lbs. per sq. in. on **Full Diam.**

Size	T. S.	Shear	Size	T. S.	Shear
$\frac{1}{4}$	216	392	$1\frac{3}{4}$	17,460	19,240
$\frac{5}{16}$	450	608	$1\frac{7}{8}$	20,510	22,088
$\frac{3}{8}$	680	880	2	23,020	25,136
$\frac{7}{16}$	930	1,200	$2\frac{1}{4}$	30,230	31,808
$\frac{1}{2}$	1,260	1,568	$2\frac{1}{2}$	37,190	39,272
$\frac{9}{16}$	1,620	1,984	$2\frac{3}{4}$	46,200	47,520
$\frac{5}{8}$	2,020	2,456	3	54,280	56,552
$\frac{3}{4}$	3,020	3,536	$3\frac{1}{4}$	65,100	66,368
$\frac{7}{8}$	4,200	4,808	$3\frac{1}{2}$	75,480	76,968
1	5,500	6,680	$3\frac{3}{4}$	86,410	88,360
$1\frac{1}{8}$	6,940	7,952	4	99,630	100,528
$1\frac{1}{4}$	8,930	9,816	$4\frac{1}{4}$	113,400	113,488
$1\frac{3}{8}$	10,570	11,880	$4\frac{1}{2}$	127,750	127,232
$1\frac{1}{2}$	12,950	14,136	$4\frac{3}{4}$	142,150	141,768
$1\frac{5}{8}$	15,150	16,592	5	157,600	157,080

Tensile Stress at 10,000 lbs. per sq. in. at **Root of "V" Thread.**

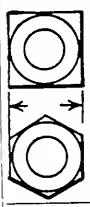
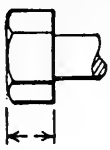
Size	Area at Root of Thread	T. S.	Size	Area at Root of Thread	T. S.
$\frac{1}{4}$	.021	210	$1\frac{3}{4}$	1.547	15,470
$\frac{5}{16}$	.036	360	$1\frac{7}{8}$	1.744	17,440
$\frac{3}{8}$	.056	560	2	2.051	20,510
$\frac{7}{16}$	.077	770	$2\frac{1}{4}$	2.746	27,460
$\frac{1}{2}$	.099	990	$2\frac{1}{2}$	3.365	33,650
$\frac{9}{16}$	.137	1,370	$2\frac{3}{4}$	4.227	42,270
$\frac{5}{8}$	.172	1,720	3	4.948	49,480
$\frac{3}{4}$	.261	2,610	$3\frac{1}{4}$	5.983	59,830
$\frac{7}{8}$	.366	3,660	$3\frac{1}{2}$	6.928	69,280
1	.481	4,810	$3\frac{3}{4}$	7.892	78,920
$1\frac{1}{8}$	.605	6,050	4	9.186	91,860
$1\frac{1}{4}$	.786	7,860	$4\frac{1}{4}$	10.460	104,600
$1\frac{3}{8}$	.926	9,260	$4\frac{1}{2}$	11.760	117,600
$1\frac{1}{2}$	1.152	11,520	$4\frac{3}{4}$	13.140	131,400
$1\frac{5}{8}$	1.284	12,840	5	14.590	145,900

For diameters at root of thread see following tables.

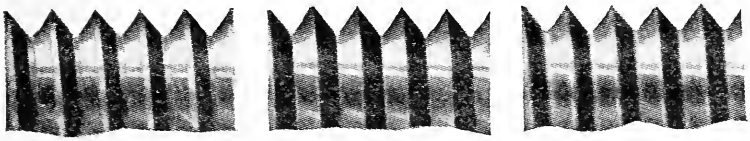
The following cuts and information relative to bolts, nuts, washers and weights of steel have been reproduced by permission of the Upson Nut Co.

U. S. STANDARD THREADS, BOLTS, AND NUTS

The tap drill diameters in the table provide for a slight clearance at the root of the thread in order to facilitate tapping and reduce tap breakages. If full threads are required, use the diameters at the root of the threads for the tap drill diameters instead.

Diam. of Bolt	No. of Th'ds Per Inch	Diam. at Root of Thread	Area in Sq. Inches		Dimensions of Nuts and Bolt Heads				
			Of Bolt	At Rt. of Th'd					
1/4	20	0.185	0.049	0.027	1/2	0.578	0.707	1/4	1/4
5/16	18	0.240	0.076	0.045	19/32	0.686	0.840	5/16	1 9/64
3/8	16	0.294	0.110	0.068	1 1/16	0.794	0.972	3/8	1 1/32
7/16	14	0.345	0.150	0.093	25/32	0.902	1.105	7/16	2 5/64
1/2	13	0.400	0.196	0.126	7/8	1.011	1.237	1/2	7/16
9/16	12	0.454	0.248	0.162	31/32	1.119	1.370	9/16	3 1/64
5/8	11	0.507	0.307	0.202	1 1/16	1.227	1.502	5/8	1 7/32
3/4	10	0.620	0.442	0.302	1 1/4	1.444	1.768	3/4	5/8
7/8	9	0.731	0.601	0.419	1 7/16	1.660	2.033	7/8	2 3/32
1	8	0.838	0.785	0.551	1 5/8	1.877	2.298	1	1 3/64
1 1/8	7	0.939	0.994	0.694	1 13/16	2.093	2.563	1 1/8	2 9/32
1 1/4	7	1.064	1.227	0.893	2	2.310	2.828	1 1/4	1
1 3/8	6	1.158	1.485	1.057	2 3/16	2.527	3.093	1 3/8	1 3/32
1 1/2	6	1.283	1.767	1.295	2 3/8	2.743	3.358	1 1/2	1 3/16
1 5/8	5 1/2	1.389	2.074	1.515	2 9/16	2.960	3.623	1 5/8	1 9/32
1 3/4	5	1.490	2.405	1.746	2 3/4	3.176	3.889	1 3/4	1 3/8
1 7/8	5	1.615	2.761	2.051	2 15/16	3.393	4.154	1 7/8	1 15/32
2	4 1/2	1.711	3.142	2.302	3 1/8	3.609	4.419	2	1 9/16
2 1/4	4 1/2	1.961	3.976	3.023	3 1/2	4.043	4.949	2 1/4	1 3/4
2 1/2	4	2.175	4.909	3.719	3 7/8	4.476	5.479	2 1/2	1 15/16
2 3/4	4	2.425	5.940	4.620	4 1/4	4.909	6.010	2 3/4	2 1/8
3	3 1/2	2.629	7.069	5.428	4 5/8	5.342	6.540	3	2 5/16
3 1/4	3 1/2	2.879	8.296	6.510	5	5.775	7.070	3 1/4	2 1/2
3 1/2	3 1/4	3.100	9.621	7.548	5 3/8	6.208	7.600	3 1/2	2 11/16
3 3/4	3	3.317	11.045	8.641	5 3/4	6.641	8.131	3 3/4	2 7/8
4	3	3.567	12.566	9.963	6 1/8	7.074	8.661	4	3 1/16
4 1/4	2 7/8	3.798	14.186	11.340	6 1/2	7.508	9.191	4 1/4	3 1/4
4 1/2	2 3/4	4.028	15.904	12.750	6 7/8	7.941	9.721	4 1/2	3 7/16
4 3/4	2 5/8	4.255	17.721	14.215	7 1/4	8.374	10.252	4 3/4	3 5/8
5	2 1/2	4.480	19.635	15.760	7 5/8	8.807	10.782	5	3 13/16

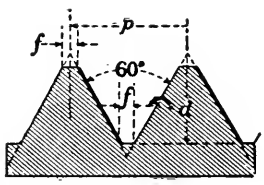
Forms and Dimensions of Threads



Diam. Inches	United States Standard			V Standard		Whitworth Standard			S. A. E. & A. L. A. M.	
	Threads per Inch	Diam. at Root of Thread	Width of Flat	Threads per Inch	Diam. at Root of Thread	Threads per Inch	Diam. at Root of Thread	Radius Inch	Threads per Inch	Diam. at Root of Thread
1/4	20	.185	.0062	20	.163	20	.186	.0069	28	.2036
5/16	18	.240	.0069	18	.216	18	.241	.0076	24	.2584
3/8	16	.294	.0078	16	.267	16	.295	.0086	24	.3269
7/16	14	.345	.0089	14	.314	14	.346	.0098	20	.3726
1/2	13	.400	.0096	12	.356	12	.393	.0114	20	.4351
9/16	12	.454	.0104	12	.418	12	.456	.0114	18	.4903
5/8	11	.507	.0114	11	.468	11	.508	.0125	18	.5528
11/16	..	...	....	...	...	..	...	....	16	.6063
3/4	10	.620	.0125	10	.577	10	.622	.0137	16	.6688
7/8	9	.731	.0139	9	.683	9	.732	.0152	14	.7822
7/8	..	...	....	..	...	..	...	....	18	.8028
1	8	.838	.0156	8	.783	8	.840	.0176	12	.8918
1	.	...	....	..	...	..	...	....	14	.9072
1 1/8	7	.939	.0179	7	.878	7	.942	.0196	12	1.0168
1 1/4	7	1.064	.0179	7	1.003	7	1.067	.0196	12	1.1418
1 3/8	6	1.159	.0208	6	1.086	6	1.161	0229	12	1.2668
1 1/2	6	1.284	.0208	6	1.211	6	1.286	.0229	12	1.3918
1 5/8	5 1/2	1.389	.0227	5	1.279	5	1.368	.0275	..	.....
1 3/4	5	1.490	.0250	5	1.404	5	1.494	.0275	..	.....
1 7/8	5	1.615	.0250	4 1/2	1.490	4 1/2	1.590	.0305	..	.....
2	4 1/2	1.711	.0278	4 1/2	1.616	4 1/2	1.715	.0305	..	.....
2 1/4	4 1/2	1.961	.0278	4 1/2	1.87	4	1.930	.0343	..	.....
2 1/2	4	2.175	.0313	4	2.07	4	2.180	.0343	..	.....
2 3/4	4	2.425	.0313	4	2.32	3 1/2	2.384	.0393	..	.....
3	3 1/2	2.629	.0357	3 1/2	2.51	3 1/2	2.634	.0393	..	.....
3 1/4	3 1/2	2.879	.0357	3 1/2	2.76	3 1/4	2.856	.0422	..	.....
3 1/2	3 1/4	3.100	.0385	3 1/4	2.97	3 1/4	3.105	.0422	..	.....
3 3/4	3	3.317	.0417	3	3.17	3	3.320	.0458	..	.....
4	3	3.567	.0417	3	3.42	3	3.573	.0458	..	.....

S. A. E. (Society of Automobile Engineers) Standard and A. L. A. M. (Association of Licensed Automobile Manufacturers) Standard threads are same angle and shape as United States Standard, differing only in number of threads per inch.

United States Standard Thread



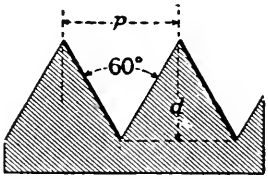
Formula

$$p = \text{pitch} = \frac{1}{\text{No. threads per inch}}$$

$$d = \text{depth} = p \times .64952$$

$$f = \text{flat} = \frac{p}{8}$$

Sharp "V" Thread

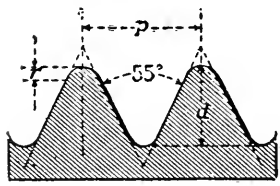


Formula

$$p = \text{pitch} = \frac{1}{\text{No. threads per inch}}$$

$$d = \text{depth} = p \times .86603$$

Whitworth Standard Thread



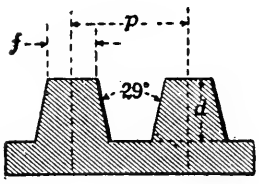
Formula

$$p = \text{pitch} = \frac{1}{\text{No. threads per inch}}$$

$$d = \text{depth} = p \times .64033$$

$$b = \text{radius} = p \times .1373$$

Acme Standard Screw Thread



Formula

$$p = \text{pitch} = \frac{1}{\text{No. threads per inch}}$$

$$d = \text{depth} = \tfrac{1}{2}p + .010$$

$$b = \text{flat on top of thread} = p \times .3707$$

Cast Washers

Government (O. G.) Standard

Diameter Inches	Hole Inches	Thickness Inches	Bolt Inches	Weight Pounds
2¼	⅝	11/16	½	½
2¾	¾	¾	⅝	⅝
3	⅞	13/16	¾	¾
3½	1	⅞	⅞	1¼
4	1⅛	15/16	1	1⅜
4½	1¼	1	1⅛	2¼
5	1⅜	1⅛	1¼	3
6	1¾	1¼	1½	5

Standard Wrought Washers

U. S. Standard Sizes

In effect January 20, 1910

Diameter Inches	Hole Inches	Thickness of Wire Gauge (Birmingham) No	Bolt Inches	Price per Lb. in 200 Lb. Kegs Cents	Number in 100 Pound	Weight per 1,000 Pieces Pounds
9/16	¼	18	3/16	14.	39 400	2 53
¾	5/16	16	¼	12.2	15 600	6.4
⅞	⅜	16	5/16	11.4	11,250	8 8
1	7/16	14	⅜	10.5	6 800	14.7
1¼	½	14	7/16	9.8	4.300	21.
1⅜	9/16	12	½	9.4	2,600	38.4
1½	⅝	12	9/16	9.3	2,250	44.4
1¾	11/16	10	⅝	9.2	1,300	77.
2	13/16	9	¾	9.1	900	111.
2¼	15/16	8	⅞	9.	782	153.
2½	1 1/16	8	1	9.	568	176.
2¾	1¼	8	1⅛	9.	473	211.
3	1⅜	8	1¼	9.2	364	261.
3¼	1½	7	1⅜	9.2	275	364.
3½	1⅝	7	1½	9.2	156	390.
3¾	1¾	7	1⅝	9.5	220	454.
4	1⅞	7	1¾	9.5	197	508.
4¼	2	7	1⅞	9.5	174	575.
4½	2⅛	7	2	9.5	160	625.
4¾	2⅜	5	2¼	10.5	122	820.
5	2⅝	4	2½	10.5	106	943.

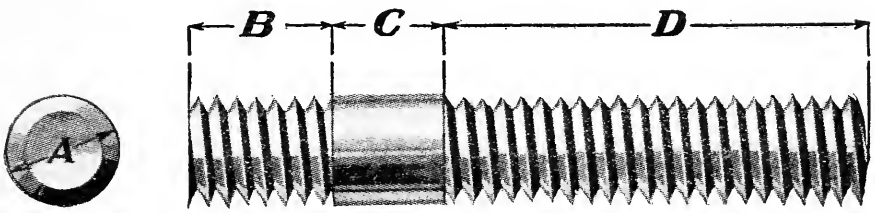
Weights of Round, Square and Hexagon Steel

Weight of one Cubic Inch = .2836 lbs. Weight of one Cubic Foot = 490 lbs.

Thickness or Diameter	Round Weight per Inch	Square Weight per Inch	Hexagon Weight per Inch	Thickness or Diameter	Round Weight per Inch	Square Weight per Inch	Hexagon Weight per Inch
1/32	.0002	.0003	.0002	1 7/8	.7831	.9970	.8635
1/16	.0009	.0011	.0010	1 15/16	.8361	1.0646	.9220
3/32	.0020	.0025	.0022	2	.8910	1.1342	.9825
1/8	.0035	.0044	.0038	2 1/16	.9475	1.2064	1.0448
5/32	.0054	.0069	.0060	2 1/8	1.0058	1.2806	1.1091
3/16	.0078	.0101	.0086	2 3/16	1.0658	1.3570	1.1753
7/32	.0107	.0136	.0118	2 1/4	1.1276	1.4357	1.2434
1/4	.0139	.0177	.0154	2 5/16	1.1911	1.5165	1.3135
9/32	.0176	.0224	.0194	2 3/8	1.2564	1.6569	1.3854
5/16	.0218	.0277	.0240	2 7/16	1.3234	1.6849	1.4593
11/32	.0263	.0335	.0290	2 1/2	1.3921	1.7724	1.5351
3/8	.0313	.0405	.0345	2 5/8	1.5348	1.9541	1.6924
13/32	.0368	.0466	.0405	2 3/4	1.6845	2.1446	1.8574
7/16	.0426	.0543	.0470	2 7/8	1.8411	2.3441	2.0304
15/32	.0489	.0623	.0540	3	2.0046	2.5548	2.2105
1/2	.0557	.0709	.0614	3 1/8	2.1752	2.7719	2.3986
17/32	.0629	.0800	.0693	3 1/4	2.3527	2.9954	2.5918
9/16	.0705	.0897	.0777	3 3/8	2.5371	3.2303	2.7977
19/32	.0785	.1036	.0866	3 1/2	2.7286	3.4740	3.0083
5/8	.0870	.1108	.0959	3 5/8	2.9269	3.7265	3.2275
21/32	.0959	.1221	.1058	3 3/4	3.1323	3.9880	3.4539
11/16	.1053	.1340	.1161	3 7/8	3.3446	4.2582	3.6880
23/32	.1151	.1465	.1270	4	3.5638	4.5374	3.9298
3/4	.1253	.1622	.1382	4 1/8	3.7900	4.8254	4.1792
25/32	.1359	.1732	.1499	4 1/4	4.0232	5.1223	4.4364
13/16	.1470	.1872	.1620	4 3/8	4.2634	5.4280	4.7011
27/32	.1586	.2019	.1749	4 1/2	4.5105	5.7426	4.9736
7/8	.1705	.2171	.1880	4 5/8	4.7645	6.0662	5.2538
29/32	.1829	.2329	.2015	4 3/4	5.0255	6.6276	5.5416
15/16	.1958	.2492	.2159	4 7/8	5.2935	6.7397	5.8371
31/32	.2090	.2661	.2305	5	5.5685	7.0897	6.1403
1	.2227	.2836	.2456	5 1/8	5.8504	7.4496	6.4511
1 1/16	.2515	.3201	.2773	5 1/4	6.1392	7.8164	6.7697
1 1/8	.2819	.3589	.3109	5 3/8	6.4351	8.1930	7.0959
1 3/16	.3141	4142	.3464	5 1/2	6.7379	8.5786	7.4298
1 1/4	.3480	4431	.3838	5 5/8	7.0476	8.9729	7.7713
1 5/16	.3837	.4885	.4231	5 3/4	7.3643	9.3762	8.1214
1 3/8	.4211	.5362	.4643	5 7/8	7.6880	9.7883	8.4774
1 7/16	.4603	.5860	.5076	6	8.0186	10.2192	8.8420
1 1/2	.5012	.6487	.5526	6 1/4	8.7007	11.0877	9.5943
1 9/16	.5438	.6930	.5996	6 1/2	9.4107	11.9817	10.3673
1 5/8	.5882	.7489	.6480	6 3/4	10.1485	12.9211	11.1908
1 11/16	.6343	.8076	.6994	7	10.9142	13.8960	12.0351
1 3/4	.6821	.8685	.7521	7 1/2	12.5291	15.9520	13.8158
1 13/16	.7317	.9316	.8069	8	14.2553	18.1497	15.7192

Multiply above weights by 1.125 for high speed steel, .993 for wrought iron, .918 for cast iron 1.0331 for cast brass, 1.1209 for copper, and 1.1748 for phosphor bronze.

Formula of Standard Studs



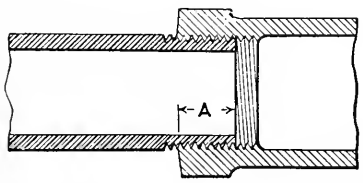
A = Diameter of Stud
B = A + ⅛ in.
C = A
D = Whole length of Stud — (B + C)

Thread on B is steam tight unless otherwise ordered
Studs furnished in either U. S. Standard or V Threads

The following information on pipe thread, pipe and boiler tubes has been taken, by permission, from Crane Company's catalogue.

LENGTH OF THREAD ON PIPE THAT IS SCREWED INTO VALVES OR FITTINGS TO MAKE A TIGHT JOINT

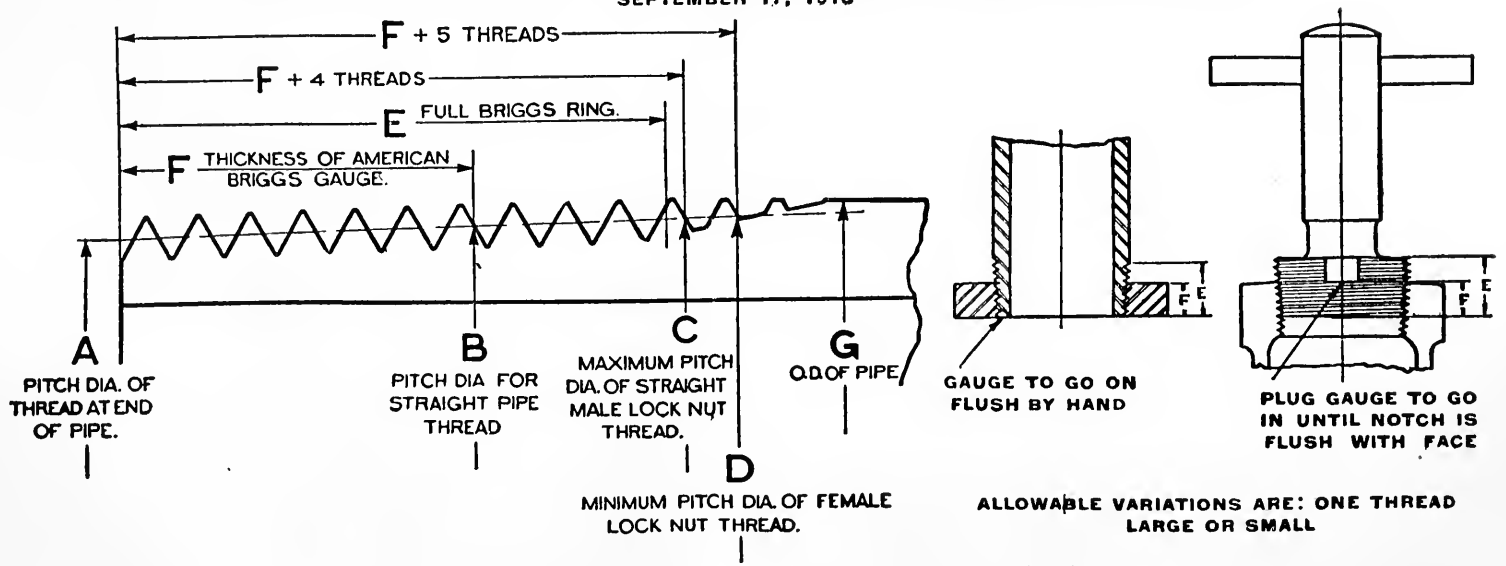
Dimensions given do not allow for variation in tapping or threading



Size Inches	Dimension A Inches	Size Inches	Dimension A Inches
$\frac{1}{8}$	$\frac{1}{4}$	$3\frac{1}{2}$	$1\frac{1}{16}$
$\frac{1}{4}$	$\frac{3}{8}$	4	$1\frac{1}{16}$
$\frac{3}{8}$	$\frac{3}{8}$	$4\frac{1}{2}$	$1\frac{1}{8}$
$\frac{1}{2}$	$\frac{1}{2}$	5	$1\frac{3}{16}$
$\frac{3}{4}$	$\frac{1}{2}$	6	$1\frac{1}{4}$
1	$\frac{9}{16}$	7	$1\frac{1}{4}$
$1\frac{1}{4}$	$\frac{5}{8}$	8	$1\frac{5}{16}$
$1\frac{1}{2}$	$\frac{5}{8}$	9	$1\frac{3}{8}$
2	$\frac{11}{16}$	10	$1\frac{1}{2}$
$2\frac{1}{2}$	$\frac{15}{16}$	12	$1\frac{5}{8}$
3	1		

AMERICAN BRIGGS STANDARD FOR TAPER AND STRAIGHT PIPE THREADS AND LOCK-NUT THREADS

ADOPTED BY THE COMMITTEE OF MANUFACTURERS ON STANDARDIZATION OF FITTINGS AND VALVES AND THE AMERICAN SOCIETY OF AMERICAN ENGINEERS
SEPTEMBER 17, 1913


F + 5 THREADS
F + 4 THREADS
E FULL BRIGGS RING.
F THICKNESS OF AMERICAN BRIGGS GAUGE.
A
PITCH DIA. OF THREAD AT END OF PIPE.
B
PITCH DIA FOR STRAIGHT PIPE THREAD
C
MAXIMUM PITCH DIA. OF STRAIGHT MALE LOCK NUT THREAD.
G
O.D. OF PIPE
D
MINIMUM PITCH DIA. OF FEMALE LOCK NUT THREAD.
GAUGE TO GO ON FLUSH BY HAND
PLUG GAUGE TO GO IN UNTIL NOTCH IS FLUSH WITH FACE
ALLOWABLE VARIATIONS ARE: ONE THREAD LARGE OR SMALL

A equals $G-(0.05G+1.9)\times\frac{1}{N}+\frac{0.8}{N}$

B equals $A+(F\times.0625)$

C equals $B+\left(\frac{4}{N}\times.0625\right)$

D equals $B+\left(\frac{5}{N}\times.0625\right)$

E equals $(0.8G+4.8)\times\frac{1}{N}+\frac{2}{N}$

F equals American Briggs Standard.
N equals Number of threads per inch.
Total Taper ¾ inch per foot.

Depth of Thread $\frac{0.8}{N}$

Size	A	B	C	D	E	F	G	Depth of Thread	Threads per Inch
1/8	.36350	.37475	.38400	.38632	.2638	.180	.405	.02962	27
1/4	.47739	.48989	.50378	.50725	.4018	.200	.540	.04444	18
3/8	.61201	.62701	.64090	.64437	.4078	.240	.675	.04444	18
1/2	.75843	.77843	.79628	.80075	.5337	.320	.840	.05714	14
3/4	.96768	.98886	1.00671	1.01118	.5457	.339	1.050	.05714	14
1	1.21363	1.23863	1.26036	1.26580	.6828	.400	1.315	.06956	11 1/2
1 1/4	1.55713	1.58338	1.60511	1.61055	.7068	.420	1.660	.06956	11 1/2
1 1/2	1.79609	1.82234	1.84407	1.84951	.7235	.420	1.900	.06956	11 1/2
2	2.26902	2.29627	2.31801	2.32344	.7565	.436	2.375	.06956	11 1/2
2 1/2	2.71954	2.76216	2.79341	2.80122	1.1375	.682	2.875	.100	8
3	3.34063	3.38850	3.41975	3.42756	1.2000	.766	3.500	.100	8
3 1/2	3.83750	3.88881	3.92006	3.92787	1.2500	.821	4.000	.100	8
4	4.33438	4.38713	4.41838	4.42619	1.3000	.844	4.500	.100	8
4 1/2	4.83125	4.88593	4.91718	4.92499	1.3500	.875	5.000	.100	8
5	5.39074	5.44930	5.48055	5.48836	1.4063	.937	5.563	.100	8
6	6.44610	6.50597	6.53722	6.54503	1.5125	.958	6.625	.100	8
7	7.43985	7.50235	7.53360	7.54141	1.6125	1.000	7.625	.100	8
8	8.43360	8.50003	8.53128	8.53909	1.7125	1.063	8.625	.100	8
9	9.42735	9.49797	9.52922	9.53703	1.8125	1.130	9.625	.100	8
10	10.54532	10.62094	10.65219	10.66000	1.9250	1.210	10.750	.100	8
11	11.53907	11.61938	11.65063	11.65844	2.0250	1.285	11.750	.100	8
12	12.53282	12.61782	12.64907	12.65688	2.1250	1.360	12.750	.100	8
14 O. D.	13.7750	13.87262	13.90387	13.91168	2.250	1.562	14.00	.100	8
15 O. D.	14.76875	14.87418	14.90543	14.91324	2.350	1.687	15.00	.100	8
16 O. D.	15.76250	15.87575	15.90700	15.91481	2.450	1.812	16.00	.100	8
17 O. D.	16.75625	16.87500	16.90625	16.91406	2.550	1.900	17.00	.100	8
18 O. D.	17.7500	17.87500	17.90625	17.91406	2.650	2.000	18.00	.100	8
20 O. D.	19.73750	19.87031	19.90156	19.90937	2.850	2.125	20.00	.100	8
22 O. D.	21.72500	21.86562	21.89687	21.90468	3.050	2.250	22.00	.100	8
24 O. D.	23.71250	23.86093	23.89218	23.89999	3.250	2.375	24.00	.100	8

STANDARD WROUGHT PIPE — Table of Standard Dimensions

Size	Diameters		Nominal Thickness	Circumference		Transverse Areas			Length of Pipe per Square Foot of		Length of Pipe Containing One Cubic Foot	Nominal Weight Per Foot		Number of Threads Per Inch of Screw
	External	Approximate Internal		External	Internal	External	Internal	Metal	External Surface	Internal Surface		Plain Ends	Threaded and Coupled	
Inches	Inches	Inches	Inches	Inches	Inches	Sq. Ins.	Sq. Ins.	Sq. Ins.	Feet	Feet	Feet			
$\frac{1}{8}$	.405	.269	.068	1.272	.845	.129	.057	.072	9.431	14.199	2533.775	.244	.245	27
$\frac{1}{4}$	.540	.364	.088	1.696	1.144	.229	.104	.125	7.073	10.493	1383.789	.424	.425	18
$\frac{3}{8}$	.675	.493	.091	2.121	1.549	.358	.191	.167	5.658	7.747	754.360	.567	.568	18
$\frac{1}{2}$	.840	.622	.109	2.639	1.954	.554	.304	.250	4.547	6.141	473.906	.850	.852	14
$\frac{3}{4}$	1.050	.824	.113	3.299	2.589	.866	.533	.333	3.637	4.635	270.034	1.130	1.134	14
1	1.315	1.049	.133	4.131	3.296	1.358	.864	.494	2.904	3.641	166.618	1.678	1.684	$11\frac{1}{2}$
$1\frac{1}{4}$	1.660	1.380	.140	5.215	4.335	2.164	1.495	.669	2.301	2.767	96.275	2.272	2.281	$11\frac{1}{2}$
$1\frac{1}{2}$	1.900	1.610	.145	5.969	5.058	2.835	2.036	.799	2.010	2.372	70.733	2.717	2.731	$11\frac{1}{2}$
2	2.375	2.067	.154	7.461	6.494	4.430	3.355	1.075	1.608	1.847	42.913	3.652	3.678	$11\frac{1}{2}$
$2\frac{1}{2}$	2.875	2.469	.203	9.032	7.757	6.492	4.788	1.704	1.328	1.547	30.077	5.793	5.819	8
3	3.500	3.068	.216	10.996	9.638	9.621	7.393	2.228	1.091	1.245	19.479	7.575	7.616	8
$3\frac{1}{2}$	4.000	3.548	.226	12.566	11.146	12.566	9.886	2.680	.954	1.076	14.565	9.109	9.202	8
4	4.500	4.026	.237	14.137	12.648	15.904	12.730	3.174	.848	.948	11.312	10.790	10.889	8
$4\frac{1}{2}$	5.000	4.506	.247	15.708	14.156	19.635	15.947	3.688	.763	.847	9.030	12.538	12.642	8
5	5.563	5.047	.258	17.477	15.856	24.306	20.006	4.300	.686	.756	7.198	14.617	14.810	8
6	6.625	6.065	.280	20.813	19.054	34.472	28.891	5.581	.576	.629	4.984	18.974	19.185	8
7	7.625	7.023	.301	23.955	22.063	45.664	38.738	6.926	.500	.543	3.717	23.544	23.769	8
8	8.625	8.071	.277	27.096	25.356	58.426	51.161	7.265	.442	.473	2.815	24.696	25.000	8
8	8.625	7.981	.322	27.096	25.073	58.426	50.027	8.399	.442	.478	2.878	28.554	28.809	8
9	9.625	8.941	.342	30.238	28.089	72.760	62.786	9.974	.396	.427	2.294	33.907	34.188	8
10	10.750	10.192	.279	33.772	32.019	90.763	81.585	9.178	.355	.374	1.765	31.201	32.000	8
10	10.750	10.136	.307	33.772	31.843	90.763	80.691	10.072	.355	.376	1.785	34.240	35.000	8
10	10.750	10.020	.365	33.772	31.479	90.763	78.855	11.908	.355	.381	1.826	40.483	41.132	8
11	11.750	11.000	.375	36.914	34.558	108.434	95.033	13.401	.325	.347	1.515	45.557	46.247	8
12	12.750	12.090	.330	40.055	37.982	127.676	114.800	12.876	.299	.315	1.254	43.773	45.000	8
12	12.750	12.000	.375	40.055	37.699	127.676	113.097	14.579	.299	.318	1.273	49.562	50.706	8

EXTRA STRONG WROUGHT PIPE — Table of Standard Dimensions

Diameter			Nominal Thickness	Circumference		Transverse Areas			Length of Pipe per Square Foot of		Length of Pipe Containing One Cubic Foot	Nominal Weight Per Foot Plain Ends
Nominal Internal	External	Approximate Internal Diameter		External	Internal	External	Internal	Metal	External Surface	Internal Surface		
Inches	Inches	Inches	Inches	Inches	Inches	Sq. Inches	Sq. Inches	Sq. Inches	Feet	Feet	Feet	Pounds
$\frac{1}{8}$	.405	.215	.095	1.272	.675	.129	.036	.093	9.431	17.766	3966.392	.314
$\frac{1}{4}$	.540	.302	.119	1.696	.949	.229	.072	.157	7.073	12.648	2010.290	.535
$\frac{3}{8}$	.675	.423	.126	2.121	1.329	.358	.141	.217	5.658	9.030	1024.689	.738
$\frac{1}{2}$	.840	.546	.147	2.639	1.715	.554	.234	.320	4.547	6.995	615.017	1.087
$\frac{3}{4}$	1.050	.742	.154	3.299	2.331	.866	.433	.433	3.637	5.147	333.016	1.473
1	1.315	.957	.179	4.131	3.007	1.358	.719	.639	2.904	3.991	200.193	2.171
$1\frac{1}{4}$	1.660	1.278	.191	5.215	4.015	2.164	1.283	.881	2.301	2.988	112.256	2.996
$1\frac{1}{2}$	1.900	1.500	.200	5.969	4.712	2.835	1.767	1.068	2.010	2.546	81.487	3.631
2	2.375	1.939	.218	7.461	6.092	4.430	2.953	1.477	1.608	1.969	48.766	5.022
$2\frac{1}{2}$	2.875	2.323	.276	9.032	7.298	6.492	4.238	2.254	1.328	1.644	33.976	7.661
3	3.500	2.900	.300	10.996	9.111	9.621	6.605	3.016	1.091	1.317	21.801	10.252
$3\frac{1}{2}$	4.000	3.364	.318	12.566	10.568	12.566	8.888	3.678	.954	1.135	16.202	12.505
4	4.500	3.826	.337	14.137	12.020	15.904	11.497	4.407	.848	.998	12.525	14.983
$4\frac{1}{2}$	5.000	4.290	.355	15.708	13.477	19.635	14.455	5.180	.763	.890	9.962	17.611
5	5.563	4.813	.375	17.477	15.120	24.306	18.194	6.112	.686	.793	7.915	20.778
6	6.625	5.761	.432	20.813	18.099	34.472	26.067	8.405	.576	.663	5.524	28.573
7	7.625	6.625	.500	23.955	20.813	45.664	34.472	11.192	.500	.576	4.177	38.048
8	8.625	7.625	.500	27.096	23.955	58.426	45.663	12.763	.442	.500	3.154	43.388
9	9.625	8.625	.500	30.238	27.096	72.760	58.426	14.334	.396	.442	2.464	48.728
10	10.750	9.750	.500	33.772	30.631	90.763	74.662	16.101	.355	.391	1.929	54.735
11	11.750	10.750	.500	36.914	33.772	108.434	90.763	17.671	.325	.355	1.587	60.075
12	12.750	11.750	.500	40.055	36.914	127.676	108.434	19.242	.299	.325	1.328	65.415

DOUBLE EXTRA STRONG WROUGHT PIPE — Table of Standard Dimensions

Diameter			Nominal Thickness	Circumference		Transverse Areas			Length of Pipe per Square Foot of		Length of Pipe Containing One Cubic Foot	Nominal Weight Per Foot Plain Ends
Nominal Internal	External	Approximate Internal Diameter		External	Internal	External	Internal	Metal	External Surface	Internal Surface		
Inches	Inches	Inches	Inches	Inches	Inches	Sq. Inches	Sq. Inches	Sq. Inches	Feet	Feet	Feet	Pounds
$\frac{1}{2}$	.840	.252	.294	2.639	.792	.554	.050	.504	4.547	15.157	2887.164	1.714
$\frac{3}{4}$	1.050	.434	.308	3.299	1.363	.866	.148	.718	3.637	8.801	973.404	2.440
1	1.315	.599	.358	4.131	1.882	1.358	.282	1.076	2.904	6.376	510.998	3.659
$1\frac{1}{4}$	1.660	.896	.382	5.215	2.815	2.164	.630	1.534	2.301	4.263	228.379	5.214
$1\frac{1}{2}$	1.900	1.100	.400	5.969	3.456	2.835	.950	1.885	2.010	3.472	151.526	6.408
2	2.375	1.503	.436	7.461	4.722	4.430	1.774	2.656	1.608	2.541	81.162	9.029
$2\frac{1}{2}$	2.875	1.771	.552	9.032	5.564	6.492	2.464	4.028	1.328	2.156	58.457	13.695
3	3.500	2.300	.600	10.996	7.226	9.621	4.155	5.466	1.091	1.660	34.659	18.583
$3\frac{1}{2}$	4.000	2.728	.636	12.566	8.570	12.566	5.845	6.721	.954	1.400	24.637	22.850
4	4.500	3.152	.674	14.137	9.902	15.904	7.803	8.101	.848	1.211	18.454	27.541
$4\frac{1}{2}$	5.000	3.580	.710	15.708	11.247	19.635	10.066	9.569	.763	1.066	14.306	32.530
5	5.563	4.063	.750	17.477	12.764	24.306	12.966	11.340	.686	.940	11.107	38.552
6	6.625	4.897	.864	20.813	15.384	34.472	18.835	15.637	.576	.780	7.646	53.160
7	7.625	5.875	.875	23.955	18.457	45.664	27.109	18.555	.500	.650	5.312	63.079
8	8.625	6.875	.875	27.096	21.598	58.426	37.122	21.304	.442	.555	3.879	72.424

Note. — Sizes $3\frac{1}{2}$ inch and larger are made by telescoping.

STANDARD BOILER TUBES — Table of Standard Dimensions

Diameter		Nominal Thickness	Nearest B Wire Gauge	Circumference		Transverse Areas			Length of Tube per Square Foot of		Nominal Weight per Foot
External	Internal			External	Internal	External	Internal	Metal	External Surface	Internal Surface	
Inches	Inches	Inches	No.	Inches	Inches	Sq. Inches	Sq. Inches	Sq. Inches	Feet	Feet	Pounds
$1\frac{3}{4}$	1.560	.095	13	5.498	4.901	2.405	1.911	.494	2.182	2.448	1.679
2	1.810	.095	13	6.283	5.686	3.142	2.573	.569	1.909	2.110	1.932
$2\frac{1}{4}$	2.060	.095	13	7.069	6.472	3.976	3.333	.643	1.697	1.854	2.186
$2\frac{1}{2}$	2.282	.109	12	7.854	7.169	4.909	4.090	.819	1.527	1.673	2.783
$2\frac{3}{4}$	2.532	.109	12	8.639	7.955	5.940	5.036	.904	1.388	1.508	3.074
3	2.782	.109	12	9.425	8.740	7.069	6.079	.990	1.273	1.373	3.365
$3\frac{1}{4}$	3.010	.120	11	10.210	9.456	8.296	7.116	1.180	1.175	1.269	4.011
$3\frac{1}{2}$	3.260	.120	11	10.996	10.242	9.621	8.347	1.274	1.091	1.171	4.331
$3\frac{3}{4}$	3.510	.120	11	11.781	11.027	11.045	9.677	1.368	1.018	1.088	4.652
4	3.732	.134	10	12.566	11.724	12.566	10.939	1.627	.954	1.023	5.532
$4\frac{1}{2}$	4.232	.134	10	14.137	13.295	15.904	14.066	1.838	.848	.902	6.248
5	4.704	.148	9	15.708	14.778	19.635	17.379	2.256	.763	.812	7.669
6	5.670	.165	8	18.850	17.813	28.274	25.249	3.025	.636	.673	10.282
7	6.670	.165	8	21.991	20.954	38.485	34.942	3.543	.545	.572	12.044
8	7.670	.165	8	25.133	24.096	50.265	46.204	4.061	.477	.498	13.807
9	8.640	.180	7	28.274	27.143	63.617	58.629	4.988	.424	.442	16.955
10	9.594	.203	6	31.416	30.140	78.540	72.292	6.248	.381	.398	21.240
11	10.560	.220	5	34.558	33.175	95.033	87.582	7.451	.347	.361	25.329
12	11.542	.229	—	37.699	36.260	113.097	104.629	8.468	.318	.330	2.7888
13	12.524	.238	4	40.840	39.345	132.732	123.190	9.542	.293	.304	32.439

Note. — In estimating effective steam-heating or evaporating surface of tubes, the surface in contact with air or gases of combustion, according to manner of application, as whether internal or external, is to be thus taken. For heating liquids by steam, superheating steam, or transferring heat from one liquid or one gas to another, mean surface of tubes to be computed.

AMERICAN STANDARD

TEMPLATES FOR DRILLING STANDARD, LOW PRESSURE, MEDIUM AND EXTRA HEAVY FLANGED VALVES AND FLANGED FITTINGS

EFFECTIVE JANUARY 1, 1914

These Drilling Templates are in multiples of four, so that fittings may be made to face in any quarter and bolt holes straddle the center line.

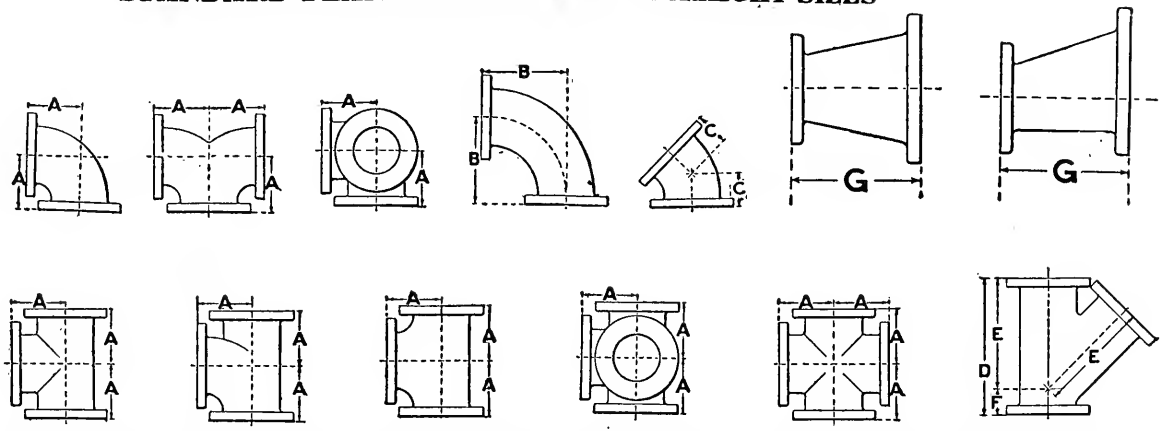
Bolt holes are drilled $\frac{1}{8}$ inch larger than nominal diameter of bolts.

Size Inches	Diameter of Flanges Inches	Thickness of Flanges Inches	Bolt Circle Inches	Number of Bolts	Size of Bolts Inches	Length of Bolts Inches	Length of Studs with 2 Nuts, Inches	Size Inches	Diameter of Flanges Inches	Thickness of Flanges Inches	Bolt Circle Inches	Number of Bolts	Size of Bolts Inches	Length of Bolts Inches	Length of Studs with 2 Nuts, Inches
1	4	$\frac{7}{16}$	3	4	$\frac{7}{16}$	$1\frac{1}{2}$		42	53	$2\frac{5}{8}$	$49\frac{1}{2}$	36	$1\frac{5}{8}$	$7\frac{1}{2}$	$9\frac{1}{2}$
$1\frac{1}{4}$	$4\frac{1}{2}$	$\frac{1}{2}$	$3\frac{3}{8}$	4	$\frac{7}{16}$	$1\frac{1}{2}$		44	$55\frac{1}{4}$	$2\frac{5}{8}$	$51\frac{3}{4}$	40	$1\frac{5}{8}$	$7\frac{1}{2}$	$9\frac{1}{2}$
$1\frac{1}{2}$	5	$\frac{9}{16}$	$3\frac{7}{8}$	4	$\frac{1}{2}$	$1\frac{3}{4}$		46	$57\frac{1}{4}$	$2\frac{11}{16}$	$53\frac{3}{4}$	40	$1\frac{5}{8}$	$7\frac{1}{2}$	$9\frac{1}{2}$
2	6	$\frac{5}{8}$	$4\frac{3}{4}$	4	$\frac{5}{8}$	2		48	$59\frac{1}{2}$	$2\frac{3}{4}$	56	44	$1\frac{5}{8}$	8	$9\frac{1}{2}$
$2\frac{1}{2}$	7	$\frac{11}{16}$	$5\frac{1}{2}$	4	$\frac{5}{8}$	$2\frac{1}{4}$		50	$61\frac{3}{4}$	$2\frac{3}{4}$	$58\frac{1}{4}$	44	$1\frac{3}{4}$	8	10
3	$7\frac{1}{2}$	$\frac{3}{4}$	6	4	$\frac{5}{8}$	$2\frac{1}{2}$		52	64	$2\frac{7}{8}$	$60\frac{1}{2}$	44	$1\frac{3}{4}$	8	$10\frac{1}{2}$
$3\frac{1}{2}$	$8\frac{1}{2}$	$\frac{13}{16}$	7	4	$\frac{5}{8}$	$2\frac{1}{2}$		54	$66\frac{1}{4}$	3	$62\frac{3}{4}$	44	$1\frac{3}{4}$	$8\frac{1}{2}$	$10\frac{1}{2}$
4	9	$\frac{15}{16}$	$7\frac{1}{2}$	8	$\frac{5}{8}$	$2\frac{3}{4}$		56	$68\frac{3}{4}$	3	65	48	$1\frac{3}{4}$	$8\frac{1}{2}$	$10\frac{1}{2}$
$4\frac{1}{2}$	$9\frac{1}{4}$	$\frac{15}{16}$	$7\frac{3}{4}$	8	$\frac{3}{4}$	3		58	71	$3\frac{1}{8}$	$67\frac{1}{4}$	48	$1\frac{3}{4}$	9	11
5	10	$\frac{15}{16}$	$8\frac{1}{2}$	8	$\frac{3}{4}$	3		60	73	$3\frac{1}{8}$	$69\frac{1}{4}$	52	$1\frac{3}{4}$	9	11
6	11	1	$9\frac{1}{2}$	8	$\frac{3}{4}$	3		62	$75\frac{3}{4}$	$3\frac{1}{4}$	$71\frac{3}{4}$	52	$1\frac{7}{8}$	9	$11\frac{1}{2}$
7	$12\frac{1}{2}$	$1\frac{1}{16}$	$10\frac{3}{4}$	8	$\frac{3}{4}$	3		64	78	$3\frac{1}{4}$	74	52	$1\frac{7}{8}$	9	$11\frac{1}{2}$
8	$13\frac{1}{2}$	$1\frac{1}{8}$	$11\frac{3}{4}$	8	$\frac{3}{4}$	$3\frac{1}{4}$		66	80	$3\frac{3}{8}$	76	52	$1\frac{7}{8}$	$9\frac{1}{2}$	$11\frac{1}{2}$
9	15	$1\frac{1}{8}$	$13\frac{1}{4}$	12	$\frac{3}{4}$	$3\frac{1}{4}$		68	$82\frac{1}{4}$	$3\frac{3}{8}$	$78\frac{1}{4}$	56	$1\frac{7}{8}$	$9\frac{1}{2}$	$11\frac{1}{2}$
10	16	$1\frac{3}{16}$	$14\frac{1}{4}$	12	$\frac{7}{8}$	$3\frac{1}{2}$		70	$84\frac{1}{2}$	$3\frac{1}{2}$	$80\frac{1}{2}$	56	$1\frac{7}{8}$	10	12
12	19	$1\frac{1}{4}$	17	12	$\frac{7}{8}$	$3\frac{3}{4}$		72	$86\frac{1}{2}$	$3\frac{1}{2}$	$82\frac{1}{2}$	60	$1\frac{7}{8}$	10	12
14	21	$1\frac{3}{8}$	$18\frac{3}{4}$	12	1	$4\frac{1}{4}$		74	$88\frac{1}{2}$	$3\frac{5}{8}$	$84\frac{1}{2}$	60	$1\frac{7}{8}$	10	12
15	$22\frac{1}{4}$	$1\frac{3}{8}$	20	16	1	$4\frac{1}{4}$		76	$90\frac{3}{4}$	$3\frac{5}{8}$	$86\frac{1}{2}$	60	$1\frac{7}{8}$	10	12
16	$23\frac{1}{2}$	$1\frac{7}{16}$	$21\frac{1}{4}$	16	1	$4\frac{1}{4}$		78	93	$3\frac{3}{4}$	$88\frac{3}{4}$	60	2	$10\frac{1}{2}$	$12\frac{1}{2}$
18	25	$1\frac{9}{16}$	$22\frac{3}{4}$	16	$1\frac{1}{8}$	$4\frac{3}{4}$		80	$95\frac{1}{4}$	$3\frac{3}{4}$	91	60	2	$10\frac{1}{2}$	$12\frac{1}{2}$
20	$27\frac{1}{2}$	$1\frac{11}{16}$	25	20	$1\frac{1}{8}$	5		82	$97\frac{1}{2}$	$3\frac{7}{8}$	$93\frac{1}{4}$	60	2	$10\frac{1}{2}$	13
22	$29\frac{1}{2}$	$1\frac{13}{16}$	$27\frac{1}{4}$	20	$1\frac{1}{4}$	$5\frac{1}{2}$		84	$99\frac{3}{4}$	$3\frac{7}{8}$	$95\frac{1}{2}$	64	2	$10\frac{1}{2}$	13
24	32	$1\frac{7}{8}$	$29\frac{1}{2}$	20	$1\frac{1}{4}$	$5\frac{1}{2}$		86	102	4	$97\frac{3}{4}$	64	2	11	13
26	$34\frac{1}{4}$	2	$31\frac{3}{4}$	24	$1\frac{1}{4}$	$5\frac{3}{4}$		88	$104\frac{1}{4}$	4	100	68	2	11	13
28	$36\frac{1}{2}$	$2\frac{1}{16}$	34	28	$1\frac{1}{4}$	6		90	$106\frac{1}{2}$	$4\frac{1}{8}$	$102\frac{1}{4}$	68	$2\frac{1}{8}$	$11\frac{1}{2}$	14
30	$38\frac{3}{4}$	$2\frac{1}{8}$	36	28	$1\frac{3}{8}$	$6\frac{1}{4}$		92	$108\frac{3}{4}$	$4\frac{1}{8}$	$104\frac{1}{2}$	68	$2\frac{1}{8}$	$11\frac{1}{2}$	14
32	$41\frac{3}{4}$	$2\frac{1}{4}$	$38\frac{1}{2}$	28	$1\frac{1}{2}$	$6\frac{1}{2}$		94	111	$4\frac{1}{4}$	$106\frac{1}{4}$	68	$2\frac{1}{8}$	$11\frac{1}{2}$	14
34	$43\frac{3}{4}$	$2\frac{5}{16}$	$40\frac{1}{2}$	32	$1\frac{1}{2}$	$6\frac{1}{2}$		96	$113\frac{1}{4}$	$4\frac{1}{4}$	$108\frac{1}{2}$	68	$2\frac{1}{4}$	$11\frac{1}{2}$	$14\frac{1}{2}$
36	46	$2\frac{3}{8}$	$42\frac{3}{4}$	32	$1\frac{1}{2}$	7		98	$115\frac{1}{2}$	$4\frac{3}{8}$	$110\frac{3}{4}$	68	$2\frac{1}{4}$	12	$14\frac{1}{2}$
38	$48\frac{3}{4}$	$2\frac{3}{8}$	$45\frac{1}{4}$	32	$1\frac{5}{8}$	7	9	100	$117\frac{3}{4}$	$4\frac{3}{8}$	113	68	$2\frac{1}{4}$	12	$14\frac{1}{2}$
40	$50\frac{3}{4}$	$2\frac{1}{2}$	$47\frac{1}{4}$	36	$1\frac{5}{8}$	7	9								

FOR EXTRA HEAVY FLANGED VALVES AND FITTINGS

Size Inches	Diameter of Flanges Inches	Thickness of Flanges Inches	Bolt Circle Inches	Number of Bolts	Size of Bolts Inches	Length of Bolts Inches	Length of Studs with 2 Nuts, Inches	Size Inches	Diameter of Flanges Inches	Thickness of Flanges Inches	Bolt Circle Inches	Number of Bolts	Size of Bolts Inches	Length of Bolts Inches	Length Studs with 2 Nuts, Inches
1	4½	11/16	3¼	4	½	2		16	25½	2¼	22½	20	1¼	6	
1¼	5	¾	3¾	4	½	2¼		18	28	2⅜	24¾	24	1¼	6¼	
1½	6	13/16	4½	4	⅝	2½		20	30½	2½	27	24	1⅜	6¾	
2	6½	⅞	5	4	⅝	2½		22	33	2⅝	29¼	24	1½	7	
2½	7½	1	5⅞	4	¾	3		24	36	2¾	32	24	1⅝	7½	9½
3	8¼	1⅛	6⅝	8	¾	3¼		26	38¼	2 13/16	34½	28	1⅝	8	10
3½	9	1 3/16	7¼	8	¾	3¼		28	40¾	2 15/16	37	28	1⅝	8	10
4	10	1¼	7⅞	8	¾	3½		30	43	3	39¼	28	1¾	8½	10½
4½	10½	1 5/16	8½	8	¾	3½		32	45¼	3⅛	41½	28	1⅞	9	11
5	11	1⅜	9¼	8	¾	3¾		34	47½	3¼	43½	28	1⅞	9	11½
6	12½	1 7/16	10⅝	12	¾	3¾		36	50	3⅜	46	32	1⅞	9½	11½
7	14	1½	11⅞	12	⅞	4		38	52¼	3 7/16	48	32	1⅞	9½	11½
8	15	1⅝	13	12	⅞	4¼		40	54½	3 9/16	50¼	36	1⅞	10	12
9	16¼	1¾	14	12	1	4¾		42	57	3 11/16	52¾	36	1⅞	10	12
10	17½	1⅞	15¼	16	1	5		44	59¼	3¾	55	36	2	10½	12½
12	20½	2	17¾	16	1⅛	5½		46	61½	3⅞	57¼	40	2	10½	13
14	23	2⅛	20¼	20	1⅛	5¾		48	65	4	60¾	40	2	11	13
15	24½	2 3/16	21½	20	1¼	6									

STANDARD FLANGED FITTINGS – STRAIGHT SIZES



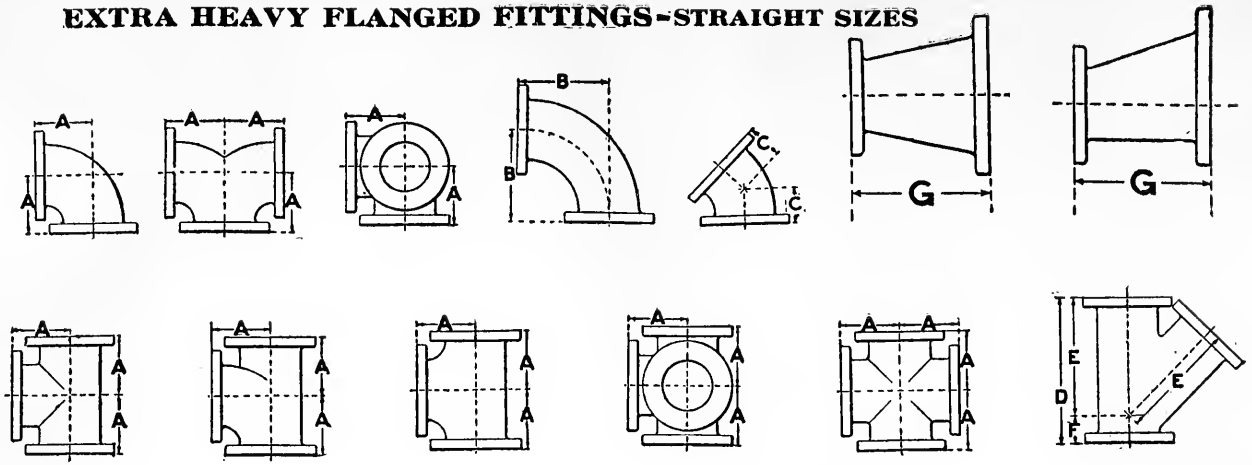
GENERAL DIMENSIONS—STANDARD FLANGED FITTINGS—STRAIGHT SIZES

(ALL DIMENSIONS ARE IN INCHES)

Size	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	15	16	18	20	22	24	26	28	30	32	34	36	38	40
AA-Face to Face, Tees and Crosses	7	7½	8	9	10	11	12	13	14	15	16	17	18	20	22	24	28	29	30	33	36	40	44	46	48	50	52	54	56	58	60
A-Center to Face, Ells, Tees and Crosses	3½	3¾	4	4½	5	5½	6	6½	7	7½	8	8½	9	10	11	12	14	14½	15	16½	18	20	22	23	24	25	26	27	28	29	30
B-Center to Face, Long Radius Ells	5	5½	6	6½	7	7½	8½	9	9½	10¼	11½	12¾	14	15½	16½	19	21½	22¾	24	26½	29	31½	34	36½	39	41½	44	46½	49	51½	54
C-Center to Face 45° Ells	1⅞	2	2¼	2½	3	3	3½	4	4	4½	5	5½	5½	6	6½	7½	7½	8	8	8½	9½	10	11	13	14	15	16	17	18	19	20
D-Face to Face Laterals	7½	8	9	10½	12	13	14½	15	15½	17	18	20½	22	24	25½	30	33	34½	36½	39	43	46	49½	53	56	59					
E-Center to Face Laterals	5¾	6¼	7	8	9½	10	11½	12	12½	13½	14½	16½	17½	19½	20½	24½	27	28½	30	32	35	37½	40½	44	46½	49					
F-Center to Face Laterals	1¾	1¾	2	2½	2½	3	3	3	3	3½	3½	4	4½	4½	5	5½	6	6	6½	7	8	8½	9	9	9½	10					
G-Face to Face Reducers						6	6½	7	7½	8	9	10	11	11½	12	14	16	17	18	19	20	22	24	26	28	30	32	34	36	38	40
Diameter of Flanges	4	4½	5	6	7	7½	8½	9	9¼	10	11	12½	13½	15	16	19	21	22¼	23½	25	27½	29½	32	34¼	36½	38¾	41¼	43¾	46	48¾	50¾
Thickness of Flanges	7/16	1/2	9/16	5/8	11/16	3/4	13/16	15/16	15/16	15/16	1	1 1/16	1 1/16	1 1/8	1 1/16	1 1/4	1 3/8	1 3/8	1 7/16	1 7/16	1 11/16	1 11/16	1 7/8	2	2 1/16	2 1/8	2 1/4	2 5/16	2 3/8	2 3/8	2 1/2
Minimum Metal Thickness of Body	7/16	7/16	7/16	7/16	7/16	7/16	7/16	1/2	1/2	1/2	9/16	5/8	5/8	11/16	3/4	13/16	7/8	7/8	1	1 1/16	1 1/8	1 3/16	1 1/4	1 5/16	1 3/8	1 7/16	1 1/2	1 5/16	1 5/8	1 11/16	1 3/4

For sizes 42″ to 100″, see manufacturer's lists.

EXTRA HEAVY FLANGED FITTINGS—STRAIGHT SIZES



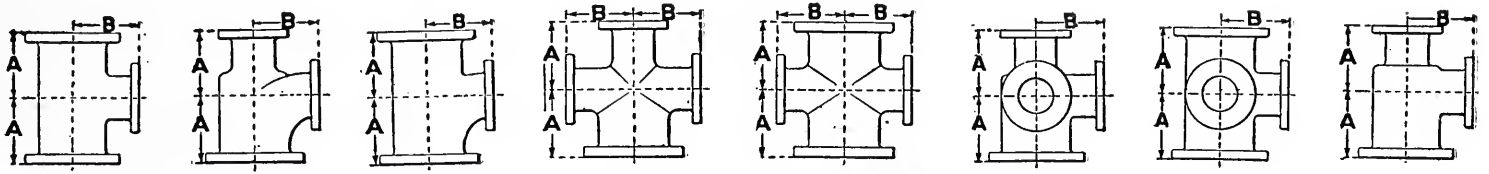
GENERAL DIMENSIONS—EXTRA HEAVY FLANGED FITTINGS—STRAIGHT SIZES

(ALL DIMENSIONS ARE IN INCHES)

Size	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	15	16	18	20	22	24	26	28	30
AA-Face to Face, Tees and Crosses	8	8½	9	10	11	12	13	14	15	16	17	18	20	21	23	26	30	31	33	36	39	41	45	48	52	55
A-Center to Face, Ells, Tees and Crosses	4	4¼	4½	5	5½	6	6½	7	7½	8	8½	9	10	10½	11½	13	15	15½	16½	18	19½	20½	22½	24	26	27½
B-Center to Face, Long Radius Ells	5	5½	6	6½	7	7½	8½	9	9½	10½	11½	12½	14	15½	16½	19	21½	22½	24	26½	29	31½	34	36½	39	41½
C-Center to Face 45° Ells	2	2½	2¾	3	3½	3½	4	4½	4½	5	5½	6	6	6½	7	8	8½	9	9½	10	10½	11	12	13	14	15
D-Face to Face, Laterals	8½	9½	11	11½	13	14	15½	16½	18	18½	21½	23½	25½	27½	29½	33½	37½	39½	42	45½	49	53	57½			
E-Center to Face, Laterals	6½	7½	8½	9	10½	11	12½	13½	14½	15	17½	19	20½	22½	24	27½	31	33	34½	37½	40½	43½	47½			
F-Center to Face, Laterals	2	2½	2½	2½	2½	3	3	3	3½	3½	4	4½	5	5	5½	6	6½	6½	7½	8	8½	9½	10			
G-Face to Face, Reducers						6	6½	7	7½	8	9	10	11	11½	12	14	16	17	18	19	20	22	24	26	28	30
Diameter of Flanges	4½	5	6	6½	7½	8¼	9	10	10½	11	12½	14	15	16½	17½	20½	23	24½	25½	28	30½	33	36	38½	40½	43
Thickness of Flanges	11/16	13/16	15/16	1	1 1/16	1 1/8	1 3/16	1 1/4	1 5/16	1 3/8	1 7/16	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/8	2 1/16	2 1/4	2 3/8	2 1/2	2 5/8	2 3/4	2 13/16	2 7/8	3
Minimum Metal Thickness of Body	1/4	1/4	1/4	1/4	5/16	5/16	5/16	3/8	3/8	11/16	7/16	7/16	7/16	1/2	1/2	1	1 1/8	1 1/16	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 13/16	1 7/8	2

For sizes from 30″ to 48″, see manufacturer's lists.

STANDARD FLANGED FITTINGS
GENERAL DIMENSIONS REDUCING TEES AND CROSSES
(ALL DIMENSIONS ARE IN INCHES)



SHORT BODY PATTERN

Size	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	15	16	18	20	22	24	26	28	30	32	34	36	38	40
*Size of Outlet and Smaller	All reducing fittings 1" to 9" inclusive have the same center to face dimensions as straight size fittings.														6	8	9	9	10	12	14	15	16	18	18	20	20	22	24	24	26
AA-Face to Face, Run															18	20	22	23	24	26	28	28	30	32	32	36	36	38	40	40	44
A-Center to Face, Run															9	10	11	11½	12	13	14	14	15	16	16	18	18	19	20	20	22
B-Center to Face, Outlet															9½	11	13	13½	14	15½	17	18	19	20	21	23	24	25	26	28	29

Size	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100
*Size of Outlet and Smaller	28	28	30	32	32	34	36	36	38	40	40	42	44	44	46	48	48	50	52	52	54	56	56	58	60	60	62	64	64	66
AA-Face to Face, Run	46	46	48	52	52	54	58	58	62	66	66	68	70	70	74	80	80	84	86	86	88	94	94	96	100	100	104	106	106	110
A-Center to Face, Run	23	23	24	26	26	27	29	29	31	33	33	34	35	35	37	40	40	42	43	43	44	47	47	48	50	50	52	53	53	55
B-Center to Face, Outlet	30	31	33	34	35	36	37	39	40	41	42	44	45	46	47	48	49	50	52	53	54	56	57	58	61	62	63	64	65	67

***LONG BODY PATTERNS** { Are used when outlets are larger than given in the above table, therefor have same dimensions as straight size fittings.

The dimensions of "Reducing Flanged Fittings" are always regulated by the reduction of the outlet.

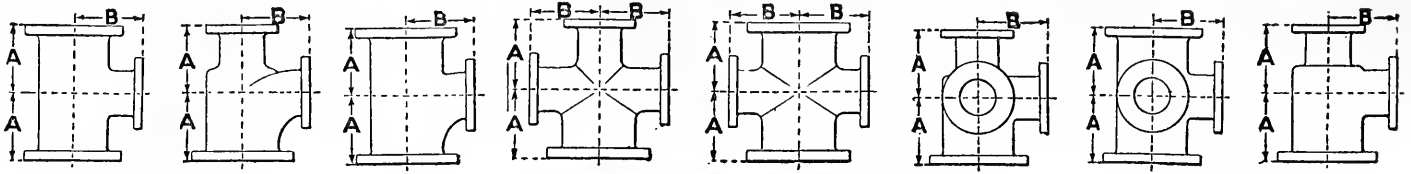
FITTINGS REDUCING ON THE RUN ONLY, the long body pattern will always be used except Double Sweep Tees, on which the reduced end is always longer than the regular fitting. Dimensions on request.

BULL HEADS OR TEES having outlets larger than the run, will be the same length center to face of all openings as a tee with all openings of the size of the outlet, for example: a 12 x 12 x 18 inch tee will be governed by the dimensions of the 18 inch long body tee; namely 16 ½ inches center to face of all openings and 33 inches face to face.

REDUCING ELBOWS, carry same center to face dimensions as regular elbows of largest straight size.

EXTRA HEAVY FLANGED FITTINGS
GENERAL DIMENSIONS REDUCING TEES AND CROSSES

(ALL DIMENSIONS ARE IN INCHES)



SHORT BODY PATTERN

Size	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	15
*Size of Outlet and Smaller	All reducing fittings 1″ to 9″ inclusive have the same center to face dimensions as straight size fittings.														6	8	9	9
AA-Face to Face, Run															18	21	23	23
A-Center to Face, Run															9	10½	11½	11½
B-Center to Face, Outlet															11	12½	14	15

Size	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
*Size of Outlet and Smaller	10	12	14	15	16	18	18	20	20	22	24	24	26	28	28	30	32
AA-Face to Face, Run	25	28	31	33	34	38	38	41	41	44	47	47	50	53	53	55	58
A-Center to Face, Run	12½	14	15½	16½	17	19	19	20½	20½	22	23½	23½	25	26½	26½	27½	29
B-Center to Face, Outlet	15½	17	18½	20	21½	23	24	25½	26½	28	29½	30½	31½	33½	34½	35½	37½

***LONG BODY PATTERNS** Are used when outlets are larger than given in the above table, therefor have same dimensions as straight size fittings.

The dimensions of "Reducing Flanged Fittings" are always regulated by the reduction of the outlet.

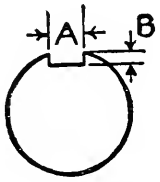
FITTINGS REDUCING ON THE RUN ONLY, the long body pattern will always be used, except Double Sweep Tees, on which the reduced end is always longer than the regular fitting. Dimensions on request.

BULLS HEADS OR TEES having outlet larger than the run, will be the same length center to face of all openings as a tee with all openings of the size of the outlet. For example; a 12 x 12 x 16 inch tee will be governed by the dimensions of the 16 inch long body tee; namely 16½ inches center to face of all openings and 33 inches face to face.

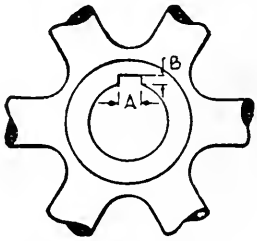
REDUCING ELBOWS carry same center to face dimension as regular elbow of largest straight size.

The following tables of key-seats and shafting horse powers in use by the Dodge Sales and Engineering Co. are reproduced by permission.

STANDARD DIMENSIONS FOR STRAIGHT KEY-SEATS IN SHAFTS



For Shafts



For Wheels

Diameter of Shaft	Key-way		Diameter of Shaft	Key-way	
	A Width	B Depth		A Width	B Depth
15/16 to 1 1/4	1/4	1/8	9 5/16 to 10 1/4	2 1/2	7/8
1 5/16 to 1 3/4	3/8	3/16	10 5/16 to 11 1/4	2 3/4	7/8
1 13/16 to 2 1/4	1/2	1/4	11 5/16 to 12 1/4	3	7/8
2 5/16 to 2 3/4	5/8	5/16	12 5/16 to 13 1/4	3 1/4	1
2 13/16 to 3 1/4	3/4	3/8	13 5/16 to 14 1/4	3 1/2	1
3 5/16 to 3 3/4	7/8	7/16	14 5/16 to 15 1/4	3 3/4	1
3 13/16 to 4 1/4	1	1/2	15 5/16 to 16 1/4	4	1
4 5/16 to 4 3/4	1 1/8	9/16	16 5/16 to 17 1/4	4 1/4	1 1/4
4 13/16 to 5 1/4	1 1/4	5/8	17 5/16 to 18 1/4	4 1/2	1 1/4
5 5/16 to 5 3/4	1 3/8	11/16	18 5/16 to 19 1/4	4 3/4	1 1/4
5 13/16 to 6 1/4	1 1/2	3/4	19 5/16 to 20 1/4	5	1 1/4
6 5/16 to 7 1/4	1 3/4	3/4	20 5/16 to 21 1/4	5 1/4	1 1/2
7 5/16 to 7 15/16	2	3/4	21 5/16 to 22 1/4	5 1/2	1 1/2
8 to 8 1/4	2	3/4	22 5/16 to 23 1/4	5 3/4	1 1/2
8 5/16 to 9 1/4	2 1/4	7/8	23 5/16 to 24 1/4	6	1 1/2

STANDARD DIMENSIONS FOR STRAIGHT KEY-WAYS IN HUBS OF COUPLINGS, CLUTCHES, PULLEYS, SHEAVES, ETC.

That are to be fitted to shafts

All Pulleys, Sheaves, etc., will be key-seated exactly the same as the shafts, as shown in the table opposite, *when they are to be fitted to shafts*, provided the bores of the pulleys, etc., do not exceed the limits shown below.

Diameter Inches	Bore Inches	Diameter Inches	Bore Inches	Diameter Inches	Bore Inches
6 to 10	3	54 1/4 to 72	6	144 1/4 to 168	13 1/2
10 1/4 to 18	3 1/2	72 1/4 to 90	7 1/2	168 1/4 to 192	15
18 1/4 to 30	4	90 1/4 to 108	9	192 1/4 to 216	16 1/2
30 1/4 to 42	4 1/2	108 1/4 to 126	10 1/2	216 1/4 to 240	18
42 1/4 to 54	5	126 1/4 to 144	12		

Tapered Key-seats. — All pulleys and sheaves will have straight key-ways unless specifically ordered otherwise.

When tapered key-seats are used, the taper will be $\frac{1}{8}$ inch to the foot, dimension "B" always applying to the deep end of key-way.

DODGE STANDARD DIMENSIONS FOR STRAIGHT KEY-SEATS IN THE HUBS OF PULLEYS, SHEAVES, GEARS AND SPROCKET WHEELS. *To be Fitted to Friction Clutch Sleeves or Quills.*

Bore of Hub	Key-seat		Bore of Hub	Key-seat		Bore of Hub	Key-seat	
	A	B		A	B		A	B
1 13/16 to 2 1/4	1/2	1/8	7 5/16 to 7 15/16	2	1/4	16 5/16 to 17 1/4	4 1/4	1/2
2 5/16 to 2 3/4	5/8	3/16	8 to 8 1/4	2	3/8	17 5/16 to 18 1/4	4 1/2	1/2
2 13/16 to 3 1/4	3/4	3/16	8 5/16 to 9 1/4	2 1/4	3/8	18 5/16 to 19 1/4	4 3/4	1/2
3 5/16 to 3 3/4	7/8	1/4	9 5/16 to 10 1/4	2 1/2	3/8	19 5/16 to 20 1/4	5	1/2
3 13/16 to 4 1/4	1	1/4	10 5/16 to 11 1/4	2 3/4	3/8	20 5/16 to 21 1/4	5 1/4	1/2
4 5/16 to 4 3/4	1 1/8	1/4	11 5/16 to 12 1/4	3	3/8	21 5/16 to 22 1/4	5 1/2	1/2
4 13/16 to 5 1/4	1 1/4	1/4	12 5/16 to 13 1/4	3 1/4	3/8	22 5/16 to 23 1/4	5 3/4	1/2
5 5/16 to 5 3/4	1 3/8	1/4	13 5/16 to 14 1/4	3 1/2	3/8	23 5/16 to 24 1/4	6	1/2
5 13/16 to 6 1/4	1 1/2	1/4	14 5/16 to 15 1/4	3 3/4	3/8			
6 5/16 to 7 1/4	1 3/4	1/4	15 5/16 to 16 1/4	4	3/8			

When pulleys, sheaves, etc., have bores in excess of table at bottom of preceding page, they will then be key-seated in accordance with the dimensions given above.

Horse Powers of Shafting Under Different Conditions

Diam. of Shaft	For Head Shafts, Heavy Strains, shafts with gears, etc. $H.P. = \frac{D^3R}{125}$								For Line Shafts, with bearings every 8 ft. $H.P. = \frac{D^3R}{75}$								For simple transmission of power with no bending strains. $H.P. = \frac{D^3R}{50}$							
	Revolutions per minute								Revolutions per minute								Revolutions per minute							
	50	100	150	200	250	300	400	500	50	100	150	200	250	300	400	500	50	100	150	200	250	300	400	500
1 3/16	0.6	1.3	1.8	2.6	3.3	4	5	6	1	2	3	4	6	7	9	11	2	3	5	7	8	10	13	17
1 7/16	1.2	2.3	4	5	6	7	9	12	2	4	6	8	10	12	16	20	3	6	9	12	15	18	24	30
1 11/16	2	4	6	8	10	11	15	19	3	6	10	13	16	19	26	32	5	10	14	19	24	29	38	48
1 15/16	3	6	9	12	15	17	23	29	5	10	15	19	24	29	39	48	7	15	22	29	36	44	58	73
2 3/16	4	8	13	17	21	25	33	42	7	14	21	28	35	42	56	70	10	21	31	42	52	63	84	105
2 7/16	6	12	17	23	29	34	46	58	10	19	29	39	48	58	77	97	14	29	43	58	72	87	116	145
2 11/16	8	15	23	31	39	46	62	78	13	26	39	52	65	78	104	129	19	39	58	78	97	117	155	194
2 15/16	10	20	30	40	50	61	81	100	17	34	51	68	85	101	135	169	25	51	76	101	127	152	203	254
3 7/16	16	32	49	65	81	97	130	162	27	54	81	108	135	163	217	271	41	81	122	163	203	244	325	406
3 15/16	24	49	73	98	122	146	195	244	41	81	122	163	204	244	326	407	61	122	183	244	305	366	488	610
4 7/16	35	70	105	140	175	210	280	...	58	117	175	233	291	350	466	...	87	175	262	350	437	524	699	...
4 15/16	48	96	144	192	240	290	385	...	80	161	241	321	401	481	642	...	120	241	361	482	602	723	963	...
5 7/16	66	133	200	265	332	400	...	...	111	222	333	444	555	666	...	...	166	333	499	666	832	998	...	...
6	86	173	260	345	432	520	...	...	144	288	432	576	720	...	...	...	216	432	648	864	1080	1296	...	...
6 1/2	110	220	330	440	550	...	...	...	183	366	549	732	915	...	...	...	275	549	824	1099	1373	...	...	...
7	137	275	412	550	686	...	...	...	229	457	686	915	1143	...	...	...	343	686	1029	1372	1715	...	...	...
7 1/2	170	337	506	675	...	...	...	...	281	563	844	1125	...	...	...	...	422	844	1266	1688	...	...	...	...
8	205	410	614	820	...	...	...	...	341	683	1024	1365	...	...	...	...	512	1024	1536	2048	...	...	...	...

STANDARD GAGE FOR SHEET AND PLATE IRON AND STEEL

FROM CIRCULAR NO. 18, BUREAU OF STANDARDS

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That for the purpose of securing uniformity, the following is established as the only standard gage for sheet and plate iron and steel in the United States of America, namely:

Number of gage	Approximate thickness in fractions of an inch	Approximate thickness in decimal parts of an inch	Approximate thickness in millimeters	Weight per square foot in ounces avoirdupois	Weight per square foot in pounds avoirdupois	Weight per square foot in kilograms	Weight per square meter in kilograms	Weight per square meter in pounds avoirdupois
0000000	1–2	.5	12.7	320	20.00	9.072	97.65	215.28
000000	15–32	.46875	11.90625	300	18.75	8.505	91.55	201.82
00000	7–16	.4375	11.1125	280	17.50	7.983	85.44	188.37
0000	13–32	.40625	10.31875	260	16.25	7.371	79.33	174.91
000	3–8	.375	9.525	240	15	6.804	73.24	161.46
00	11–32	.34375	8.73125	220	13.75	6.237	67.13	148.00
0	5–16	.3125	7.9375	200	12.50	5.67	61.03	134.55
1	9–32	.28125	7.14375	180	11.25	5.103	54.93	121.09
2	17–64	.265625	6.746875	170	10.625	4.819	51.88	114.37
3	1–4	.25	6.35	160	10	4.536	48.82	107.64
4	15–64	.234375	5.953125	150	9.375	4.252	45.77	100.91
5	7–32	.21875	5.55625	140	8.75	3.969	42.72	94.18
6	13–64	.203125	5.159375	130	8.125	3.685	39.67	87.45
7	3–16	.1875	4.7625	120	7.5	3.402	36.62	80.72
8	11–64	.171875	4.365625	110	6.875	3.118	33.57	74.00
9	5–32	.15625	3.96875	100	6.25	2.835	30.52	67.27
10	9–64	.140625	3.571875	90	5.625	2.552	27.46	60.55
11	1–8	.125	3.175	80	5	2.268	24.41	53.82
12	7–64	.109375	2.778125	70	4.375	1.984	21.36	47.09
13	3–32	.09375	2.38125	60	3.75	1.701	18.31	40.36
14	5–64	.078125	1.984375	50	3.125	1.417	15.26	33.64
15	9–128	.0703125	1.7859375	45	2.8125	1.276	13.73	30.27
16	1–16	.0625	1.5875	40	2.5	1.134	12.21	26.91
17	9–160	.05625	1.42875	36	2.25	1.021	10.99	24.22
18	1–20	.05	1.27	32	2	.9072	9.765	21.53

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STANDARD GAGE FOR SHEET AND PLATE IRON AND STEEL
(*Continued*)

Number of gage	Approximate thickness in fractions of an inch	Approximate thickness in decimal parts of an inch	Approximate thickness in millimeters	Weight per square foot in ounces avoirdupois	Weight per square foot in pounds avoirdupois	Weight per square foot in kilograms	Weight per square meter in kilograms	Weight per square meter in pounds avoirdupois
19	7–160	.04375	1.11125	28	1.75	.7988	8.544	18.84
20	3–80	.0375	.9525	24	1.50	.6804	7.324	16.15
21	11–320	.034375	.873125	22	1.375	.6237	6.713	14.80
22	1–32	.03125	.793750	20	1.25	.567	6.103	13.46
23	9–320	.028125	.714375	18	1.125	.5103	5.493	12.11
24	1–40	.025	.635	16	1	.4536	4.882	10.76
25	7–320	.021875	.555625	14	.875	.3969	4.272	9.42
26	3–160	.01875	.47625	12	.75	.3402	3.662	8.07
27	11–640	.0171875	.4365625	11	.6875	.3119	3.357	7.40
28	1–64	.015625	.396875	10	.625	.2835	3.052	6.73
29	9–640	.0140625	.3571875	9	.5625	.2551	2.746	6.05
30	1–80	.0125	.3175	8	.5	.2268	2.441	5.38
31	7–640	.0109375	.2778125	7	.4375	.1984	2.136	4.71
32	13–1280	.01015625	.25796875	6½	.40625	.1843	1.983	4.37
33	3–320	.009375	.238125	6	.375	.1701	1.831	4.04
34	11–1280	.00859375	.21828125	5½	.34375	.1559	1.678	3.70
35	5–640	.0078125	.1984375	5	.3125	.1417	1.526	3.36
36	9–1280	.00703125	.17859375	4½	.28125	.1276	1.373	3.03
37	17–2560	.006640625	.168571875	4¼	.265625	.1205	1.297	2.87
38	1–160	.00625	.15875	4	.25	.1134	1.221	2.69

And on and after July first, eighteen hundred and ninety-three, the same and no other shall be used in determining duties and taxes levied by the United States of America on sheet and plate iron and steel. But this act shall not be construed to increase duties upon any articles which may be imported.

SEC. 2. That the Secretary of the Treasury is authorized and required to prepare suitable standards in accordance herewith.

SEC. 3. That in the practical use and application of the standard gage hereby established a variation of two and one-half per cent either way may be allowed.

Approved, March 3, 1893.

Different Standards for Wire Gauge in Use in the United States

Dimensions of Sizes in Decimal Parts of an Inch

Number of Wire Gauge	Birmingham, Wire Gauge	U. S. Stand. for Plate	American or Brown & Sharpe	Washburn & Moen Mfg. Co. Worcester, Mass.	Imperial Wire Gauge	Stubs' Steel Wire	Number of Wire Gauge
000000	....	.46875	.....	....	.464	....	000000
00000	....	.4375	.....	....	.432	....	00000
0000	.454	.40625	.46	.3938	.400	....	0000
000	.425	.375	.40964	.3625	.372	....	000
00	.38	.34375	.3648	.3310	.348	....	00
0	.34	.3125	.32486	.3065	.324	....	0
1	.3	.28125	.2893	.2830	.300	.227	1
2	.284	.265625	.25763	.2625	.276	.219	2
3	.259	.25	.22942	.2437	.252	.212	3
4	.238	.234375	.20431	.2253	.232	.207	4
5	.22	.21875	.18194	.2070	.212	.204	5
6	.203	.203125	.16202	.1920	.192	.201	6
7	.18	.1875	.14428	.1770	.176	.199	7
8	.165	.171875	.12849	.1620	.160	.197	8
9	.148	.15625	.11443	.1483	.144	.194	9
10	.134	.140625	.10189	.1350	.128	.191	10
11	.12	.125	.090742	.1205	.116	.188	11
12	.109	.109375	.080808	.1055	.104	.185	12
13	.095	.09375	.071961	.0915	.092	.182	13
14	.083	.078125	.064084	.0800	.080	.180	14
15	.072	.0703125	.057068	.0720	.072	.178	15
16	.065	.0625	.05082	.0625	.064	.175	16
17	.058	.05625	.045257	.0540	.056	.172	17
18	.049	.05	.040303	.0475	.048	.168	18
19	.042	.04375	.03589	.0410	.040	.164	19
20	.035	.0375	.031961	.0348	.036	.161	20
21	.032	.034375	.028462	.03175	.032	.157	21
22	.028	.03125	.025347	.0286	.028	.155	22
23	.025	.028125	.022571	.0258	.024	.153	23
24	.022	.025	.0201	.0230	.022	.151	24
25	.02	.021875	.0179	.0204	.020	.148	25
26	.018	.01875	.01594	.0181	.018	.146	26
27	.016	.0171875	.014195	.0173	.0164	.143	27
28	.014	.015625	.012641	.0162	.0149	.139	28
29	.013	.0140625	.011257	.0150	.0136	.134	29
30	.012	.0125	.010025	.0140	.0124	.127	30
31	.01	.0109375	.008928	.0132	.0116	.120	31
32	.009	.01015625	.00795	.0128	.0108	.115	32
33	.008	.009375	.00708	.0118	.0100	.112	33
34	.007	.00859375	.006304	.0104	.0092	.110	34
35	.005	.0078125	.005614	.0095	.0084	.108	35
36	.004	.00703125	.005	.0090	.0076	.106	36
37	....	.006640625	.004453	....	.0068	.103	37
38	....	.00625	.003965	....	.0060	.101	38
39	....	.....	.003531	....	.0052	.099	39
40			.003144		0048	097	40

METRIC CONVERSION TABLES — From Circular No. 47, Bureau of Standards

Length — Hundredths of an Inch to Millimeters — From 1 to 99 Hundredths

100ths of an inch	0	1	2	3	4	5	6	7	8	9
	0	0.254	0.508	0.762	1.016	1.270	1.524	1.778	2.032	2.286
10	2.540	2.794	3.048	3.302	3.556	3.810	4.064	4.318	4.572	4.826
20	5.080	5.334	5.588	5.842	6.096	6.350	6.604	6.858	7.112	7.366
30	7.620	7.874	8.128	8.382	8.636	8.890	9.144	9.398	9.652	9.906
40	10.160	10.414	10.668	10.922	11.176	11.430	11.684	11.938	12.192	12.446
50	12.700	12.954	13.208	13.462	13.716	13.970	14.224	14.478	14.732	14.986
60	15.240	15.494	15.748	16.002	16.256	16.510	16.764	17.018	17.272	17.526
70	17.780	18.034	18.288	18.542	18.796	19.050	19.304	19.558	19.812	20.066
80	20.320	20.574	20.828	21.082	21.336	21.590	21.844	22.098	22.352	22.606
90	22.860	23.114	23.368	23.622	23.876	24.130	24.384	24.638	24.892	25.146

Length — Millimeters to Decimals of an Inch — From 1 to 99 Units

Milli-meters	0	1	2	3	4	5	6	7	8	9
	0	0.03937	0.07874	0.11811	0.15748	0.19685	0.23622	0.27559	0.31496	0.35433
10	0.39370	.43307	.47244	.51181	.55118	.59055	.62992	.66929	.70866	.74803
20	.78740	.82677	.86614	.90551	.94488	.98425	1.02362	1.06299	1.10236	1.14173
30	1.18110	1.22047	1.25984	1.29921	1.33858	1.37795	1.41732	1.45669	1.49606	1.53543
40	1.57480	1.61417	1.65354	1.69291	1.73228	1.77165	1.81102	1.85039	1.88976	1.92913
50	1.96850	2.00787	2.04724	2.08661	2.12598	2.16535	2.20472	2.24409	2.28346	2.32283
60	2.36220	2.40157	2.44094	2.48031	2.51968	2.55905	2.59842	2.63779	2.67716	2.71653
70	2.75590	2.79527	2.83464	2.87401	2.91338	2.95275	2.99212	3.03149	3.07086	3.11023
80	3.14960	3.18897	3.22834	3.26771	3.30708	3.34645	3.38582	3.42519	3.46456	3.50393
90	3.54330	3.58267	3.62204	3.66141	3.70078	3.74015	3.77952	3.81889	3.85826	3.89763

METRIC SYSTEM OF WEIGHTS AND MEASURES

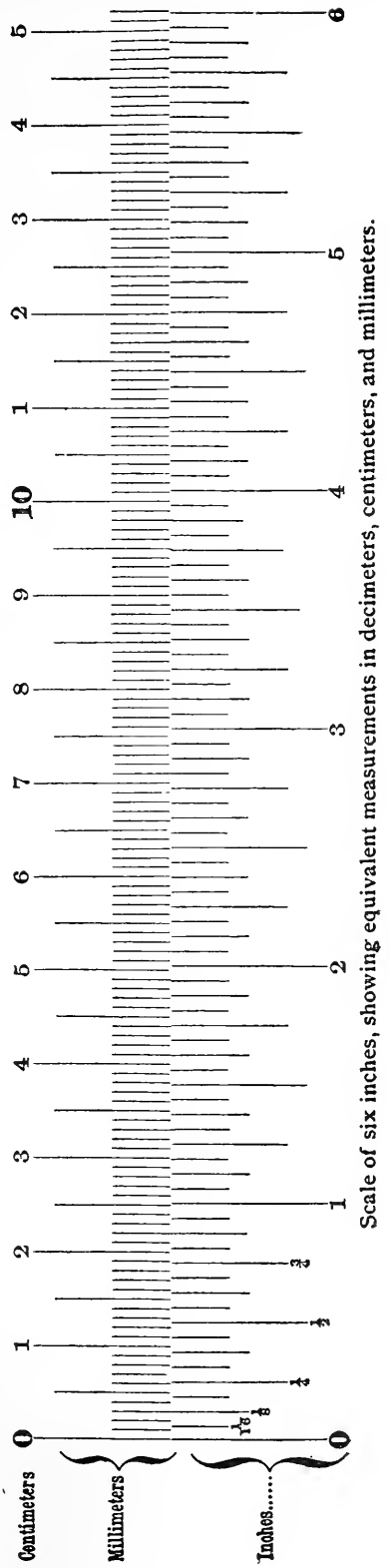
In use in all European countries except Great Britain and Russia. In use in Mexico and South America.

The Meter, unit of length, is nearly the ten-millionth part of a quadrant of a meridian, of the distance between equator and pole. The International Standard Meter is, practically, nothing else but a length defined by the distance between two lines on a platinum-iridium bar at 0° Centigrade, deposited at the International Bureau of Weights and Measures, Paris, France.

The Liter, unit of capacity, is derived from the weight of one kilogram pure water at greatest density, a cube whose edge is one-tenth of a meter, and, therefore, the one-thousandth part of a metric ton.

The Gram, unit of weight, is a cube of pure water at greatest density, whose edge is one-hundredth of a meter, and, therefore, the one-thousandth part of a kilogram and the one-millionth part of a metric ton.

One silver dollar weighs 25 grams, 1 dime = $2\frac{1}{2}$ grams, 1 five-cent nickel = 5 grams.



THE METRIC SYSTEM SIMPLIFIED

The following tables of the metric system of weights and measures have been simplified as much as possible by Mr. John Wilkes, of Nashville, Tenn., by omitting such denominations as are not in practical, everyday use in the countries where the system is used exclusively.

TABLES OF THE SYSTEM

LENGTH. — The denominations in practical use are millimeters (mm.), centimeters (cm.), meters (m.), and kilometers (km.).

10 mm. = 1 cm.; 100 cm. = 1 m.; 1000 m. = 1 km.

A decimeter is 10 cm.

WEIGHT. — The denominations in use are grams (g.), kilos* (kg.), and tons (metric tons).

1000 g. = 1 kg.; 1000 kg. = 1 metric ton.

CAPACITY. — The denominations in use are cubic centimeters (c.c.), and liters (l.).

1000 c.c. = 1 l.

A hectoliter is 100 l. (seldom used).

Relation of capacity and weight to length: A cubic decimeter is a liter, and a liter of water weighs a kilo.

* Contraction for kilogram.

WEIGHTS AND MEASURES

Troy Weight

24	Grains = 1 Pennyweight	12	Ounces = 1 Pound
20	Pwts. = 1 Ounce		

Used for weighing gold, silver, and jewels.

Apothecaries' Weight

20	Grains = 1 Scruple	8	Drams = 1 Ounce
3	Scruples = 1 Dram	12	Ounces = 1 Pound

The ounce and pound in this are the same as in Troy weight.

Avoirdupois Weight

27 11/32	Grains = 1 Dram	4	Quarters = 1 Hundredweight (cwt.)
16	Drams = 1 Ounce	20	Cwt. = 1 Long Ton
16	Ounces = 1 Pound	2240	Pounds = 1 Long Ton
28	Pounds = 1 Quarter	2000	Pounds = 1 Short Ton

Dry Measure

2	Pints = 1 Quart	4	Pecks = 1 Bushel
8	Quarts = 1 Peck	36	Bushels = 1 Chaldron

Liquid Measure

4	Gills = 1 Pint	231	Cu. In. = 1 Gallon
2	Pints = 1 Quart	31½	Gallons = 1 Barrel
4	Quarts = 1 Gallon	2	Barrels = 1 Hogshead (App.)
		63	Gallons = 1 Hogshead
		252	Gallons = 1 Tun

Long Measure

12	Inches = 1 Foot	40	Rods = 1 Furlong
3	Feet = 1 Yard	8	Furlongs = 1 Mile
5½	Yards = 1 Rod	3	Miles = 1 League

Square Measure

144	Sq. Inches = 1 Sq. Foot	160	Sq. Rods = 1 Acre
9	Sq. Ft. = 1 Sq. Yard	640	Acres = 1 Sq. Mile
30¼	Sq. Yds. = 1 Sq. Rod	43,560	Sq. Ft. = 1 Acre

Cubic Measure

1728	Cubic In. = 1 Cu. Ft.	40	Cu. Ft. = 1 Ton (U. S. shipping)
27	Cubic Ft. = 1 Cu. Yd.	44	Cu. Ft. = 1 Ton Anth. Coal
128	Cubic Ft. = 1 Cord	47	Cu. Ft. = 1 Ton Bitu. Coal
2150.42	Cubic In. = 1 U. S. Bushel	50	Cu. Ft. = 1 Ton Ashes

1 inch = 25.4001 m/m. | 1 m/m. = .03937 inches

Inches		m/m.	Inches		m/m.	Inches		m/m.
1/64	.015625	.40	25/64	.390625	9.92	49/64	.765625	19.45
1/32	.031250	.79	13/32	.40625	10.32	25/32	.78125	19.84
3/64	.046875	1.19	27/64	.421875	10.72	51/64	.796875	20.24
1/16	.06250	1.59	7/16	.43750	11.11	13/16	.8125	20.64
5/64	.078125	1.98	29/64	.453125	11.51	53/64	.828125	21.03
3/32	.093750	2.38	15/32	.468750	11.91	27/32	.84375	21.43
7/64	.109375	2.78	31/64	.484375	12.30	55/64	.859375	21.83
1/8	.125	3.17	1/2	.50	12.70	7/8	.875	22.22
9/64	.140625	3.57	33/64	.515625	13.10	57/64	.890625	22.62
5/32	.156250	3.97	17/32	.53125	13.49	29/32	.90625	23.02
11/64	.171875	4.37	35/64	.546875	13.89	59/64	.921875	23.42
3/16	.18750	4.76	9/16	.5625	14.29	15/16	.9375	23.81
13/64	.203125	5.16	37/64	.578125	14.68	61/64	.953125	24.21
7/32	.218750	5.56	19/32	.59375	15.08	31/32	.96875	24.61
15/64	.234375	5.95	39/64	.609375	15.48	63/64	.984375	25.00
1/4	.25	6.35	5/8	.625	15.87	1	1.0000	25.40
17/64	.265625	6.75	41/64	.640625	16.27			
9/32	.281250	7.14	21/32	.65625	16.67			
19/64	.296875	7.54	43/64	.671875	17.07			
5/16	.31250	7.94	11/16	.6875	17.46			
21/64	.328125	8.33	45/64	.703125	17.86			
11/32	.343750	8.73	23/32	.71875	18.26			
23/64	.359375	9.13	47/64	.734375	18.65			
3/8	.375	9.52	3/4	.75	19.05			

AREAS AND CIRCUMFERENCES OF CIRCLES

Diam.	Area	Circum.	Diam.	Area	Circum.	Diam.	Area	Circum.
1/64	.000192	04909	13/64	.032405	.63814	25/64	.119843	1.22719
1/32	.000767	.09818	7/32	.037583	.68722	13/32	.129622	1.27627
3/64	.001726	.14726	15/64	.043143	.73631	27/64	.139784	1.32536
1/16	.003068	.19635	1/4	.049087	.78540	7/16	.150330	1.37445
5/64	.004794	.24544	17/64	.055415	.83449	29/64	.161260	1.42354
3/32	.006903	.29452	9/32	.062126	.88357	15/32	.172573	1.47262
7/64	.009396	.34361	19/64	.069221	.93266	31/64	.184270	1.52171
1/8	.012272	.39270	5/16	.076699	.98175	1/2	.196350	1.57080
9/64	.015532	.44179	21/64	.084561	1.03084	33/64	.208814	1.61989
5/32	.019175	.49087	11/32	.092806	1.07992	17/32	.221661	1.66897
11/64	.023202	.53096	23/64	.101435	1.12901	35/64	.234891	1.71806
3/16	.027612	.58905	3/8	.110447	1.17810	9/16	.248505	1.76715

AREAS AND CIRCUMFERENCES OF CIRCLES (*Continued*)

Diam.	Area	Circum.	Diam.	Area	Circum.	Diam.	Area	Circum.
$\frac{3}{64}$	.26250	1.8160	$1\frac{7}{16}$	1.62295	4.5160	$3\frac{7}{8}$	11.79327	12.1737
$\frac{1}{32}$	.27688	1.8653	$1\frac{15}{32}$	1.69427	4.6142	4	12.56640	12.5664
$\frac{3}{64}$	.29165	1.9144	$1\frac{1}{2}$	1.76715	4.7124	$4\frac{1}{8}$	13.36407	12.9591
$\frac{5}{8}$	.30679	1.9635	$1\frac{17}{32}$	1.84155	4.8105	$4\frac{1}{4}$	14.18629	13.3518
$\frac{1}{64}$	.32233	2.0125	$1\frac{9}{16}$	1.91748	4.9087	$4\frac{3}{8}$	15.03305	13.7445
$\frac{2}{32}$	.33824	2.0616	$1\frac{19}{32}$	1.99495	5.0069	$4\frac{1}{2}$	15.90435	14.1372
$\frac{4}{64}$	.35454	2.1107	$1\frac{5}{8}$	2.07395	5.1051	$4\frac{5}{8}$	16.80019	14.5299
$\frac{1}{16}$	.37122	2.1598	$1\frac{21}{32}$	2.15448	5.2032	$4\frac{3}{4}$	17.72059	14.9226
$\frac{4}{64}$	.38829	2.2089	$1\frac{11}{16}$	2.23655	5.3014	$4\frac{7}{8}$	18.66552	15.3153
$\frac{2}{32}$	.40574	2.2580	$1\frac{23}{32}$	2.32015	5.3996	5	19.635	15.7080
$\frac{4}{64}$	.42357	2.3071	$1\frac{3}{4}$	2.40529	5.4978	$5\frac{1}{8}$	20.62902	16.1007
$\frac{3}{4}$	.44179	2.3562	$1\frac{25}{32}$	2.49196	5.5959	$5\frac{1}{4}$	21.64759	16.4934
$\frac{4}{64}$	.46039	2.4052	$1\frac{13}{16}$	2.58016	5.6941	$5\frac{3}{8}$	22.69069	16.8861
$\frac{2}{32}$	.47937	2.4543	$1\frac{27}{32}$	2.66990	5.7923	$5\frac{1}{2}$	23.75835	17.2788
$\frac{5}{64}$	.49874	2.5034	$1\frac{7}{8}$	2.76117	5.8905	$5\frac{5}{8}$	24.85055	17.6715
$\frac{1}{16}$	.51849	2.5525	$1\frac{29}{32}$	2.85398	5.9886	$5\frac{3}{4}$	25.96729	18.0642
$\frac{5}{64}$	.53862	2.6016	$1\frac{15}{16}$	2.94832	6.0868	$5\frac{7}{8}$	27.10857	18.4569
$\frac{2}{32}$	.55914	2.6507	$1\frac{31}{32}$	3.04419	6.1850	6	28.27440	18.8496
$\frac{5}{64}$	.58004	2.6998	2	3.14161	6.2832	$6\frac{1}{8}$	29.46477	19.2423
$\frac{7}{8}$	.60132	2.7488	$2\frac{1}{16}$	3.34102	6.4795	$6\frac{1}{4}$	30.67969	19.6350
$\frac{5}{64}$	.62299	2.7979	$2\frac{1}{8}$	3.54657	6.6759	$6\frac{3}{8}$	31.91915	20.0277
$\frac{2}{32}$	.64504	2.8470	$2\frac{3}{16}$	3.75826	6.8722	$6\frac{1}{2}$	33.18315	20.4204
$\frac{5}{64}$	.66747	2.8961	$2\frac{1}{4}$	3.97609	7.0686	$6\frac{5}{8}$	34.47169	20.8131
$\frac{1}{16}$	.69029	2.9452	$2\frac{5}{16}$	4.20005	7.2649	$6\frac{3}{4}$	35.78479	21.2058
$\frac{6}{64}$	.71349	2.9943	$2\frac{3}{8}$	4.43015	7.4613	$6\frac{7}{8}$	37.12242	21.5984
$\frac{3}{32}$	.73708	3.0434	$2\frac{7}{16}$	4.66638	7.6576	7	38.48460	21.991
$\frac{6}{64}$	.76105	3.0925	$2\frac{1}{2}$	4.90875	7.8540	$7\frac{1}{8}$	39.87132	22.384
1	.7854	3.1416	$2\frac{9}{16}$	5.15725	8.0503	$7\frac{1}{4}$	41.28259	22.776
$1\frac{1}{32}$	.83525	3.2397	$2\frac{5}{8}$	5.41189	8.2467	$7\frac{3}{8}$	42.71839	23.169
$1\frac{1}{16}$	.88664	3.3379	$2\frac{11}{16}$	5.67267	8.4430	$7\frac{1}{2}$	44.17875	23.562
$1\frac{3}{32}$	.93056	3.4361	$2\frac{3}{4}$	5.93959	8.6394	$7\frac{5}{8}$	45.66364	23.954
$1\frac{1}{8}$	.99402	3.5429	$2\frac{13}{16}$	6.21264	8.8357	$7\frac{3}{4}$	47.17309	24.347
$1\frac{5}{32}$	1.05001	3.6324	$2\frac{7}{8}$	6.49182	9.0321	$7\frac{7}{8}$	48.70707	24.740
$1\frac{3}{16}$	1.10754	3.7306	$2\frac{15}{16}$	6.77714	9.2284	8	50.26560	25.132
$1\frac{7}{32}$	1.16659	3.8288	3	7.06860	9.4248	$8\frac{1}{8}$	51.84869	25.525
$1\frac{1}{4}$	1.22719	3.9270	$3\frac{1}{8}$	7.66992	9.8175	$8\frac{1}{4}$	53.45629	25.918
$1\frac{9}{32}$	1.28931	4.0251	$3\frac{1}{4}$	8.29579	10.2102	$8\frac{3}{8}$	55.08845	26.311
$1\frac{5}{16}$	1.35297	4.1233	$3\frac{3}{8}$	8.94619	10.6029	$8\frac{1}{2}$	56.74515	26.703
$1\frac{11}{32}$	1.41817	4.2215	$3\frac{1}{2}$	9.62115	10.9956	$8\frac{5}{8}$	58.42637	27.096
$1\frac{3}{8}$	1.48489	4.3197	$3\frac{5}{8}$	10.32065	11.3883	$8\frac{3}{4}$	60.13218	27.489
$1\frac{13}{32}$	1.55316	4.4178	$3\frac{3}{4}$	11.04469	11.7810	$8\frac{7}{8}$	61.86252	27.881

AREAS AND CIRCUMFERENCES OF CIRCLES (*Continued*)

Diam.	Area	Circum.	Diam.	Area	Circum.	Diam.	Area	Circum.
9	63.61740	28.274	14	153.9384	43.982	19	283.5294	59.690
9⅛	65.39682	28.667	14⅛	156.69957	44.375	19⅛	287.27232	60.083
9¼	67.20078	29.059	14¼	159.48528	44.767	19¼	291.03979	60.475
9⅜	69.02929	29.452	14⅜	162.29554	45.160	19⅜	294.83179	60.868
9½	70.88235	29.845	14½	165.13035	45.553	19½	298.64835	61.261
9⅝	72.75994	30.237	14⅝	167.98969	45.945	19⅝	302.48945	61.653
9¾	74.66208	30.630	14¾	170.87358	46.338	19¾	306.35509	62.046
9⅞	76.58877	31.023	14⅞	173.78202	46.731	19⅞	310.24527	62.439
10	78.54	31.416	15	176.715	47.124	20	314.159	62.832
10⅛	80.51577	31.808	15⅛	179.67252	47.516	20⅛	318.09927	63.224
10¼	82.51608	32.201	15¼	182.65458	47.909	20¼	322.06309	63.617
10⅜	84.54094	32.594	15⅜	185.66119	48.302	20⅜	326.05145	64.010
10½	86.59035	32.986	15½	188.69235	48.694	20½	330.06435	64.402
10⅝	88.66429	33.379	15⅝	191.74804	49.087	20⅝	334.10179	64.795
10¾	90.76278	33.772	15¾	194.82828	49.480	20¾	338.16379	65.188
10⅞	92.88582	34.164	15⅞	197.93307	49.872	20⅞	342.25032	65.580
11	95.03340	34.557	16	201.0624	50.265	21	346.3614	65.973
11⅛	97.20552	34.950	16⅛	204.21627	50.658	21⅛	350.49702	66.366
11¼	99.40218	35.343	16¼	207.39468	51.051	21¼	354.65719	66.759
11⅜	101.62339	35.735	16⅜	210.59764	51.443	21⅜	358.84189	67.151
11½	103.86915	36.128	16½	213.82515	51.836	21½	363.05115	67.544
11⅝	106.13944	36.521	16⅝	217.07719	52.229	21⅝	367.28495	67.937
11¾	108.43428	36.913	16¾	220.35378	52.621	21¾	371.54329	68.329
11⅞	110.75367	37.306	16⅞	223.65492	53.014	21⅞	375.82617	68.722
12	113.0976	37.699	17	226.9806	53.407	22	380.1336	69.115
12⅛	115.46607	38.091	17⅛	230.33082	53.799	22⅛	384.46557	69.507
12¼	117.85908	38.484	17¼	233.70558	54.192	22¼	388.82209	69.900
12⅜	120.27664	38.877	17⅜	237.10489	54.585	22⅜	393.20315	70.293
12½	122.71875	39.270	17½	240.52875	54.978	22½	397.60875	70.685
12⅝	125.18539	39.662	17⅝	243.97714	55.370	22⅝	402.03889	71.078
12¾	127.67658	40.055	17¾	247.45008	55.763	22¾	406.49359	71.471
12⅞	130.19232	40.448	17⅞	250.94757	56.156	22⅞	410.97282	71.864
13	132.7326	40.840	18	254.4696	56.548	23	415.4766	72.256
13⅛	135.29742	41.233	18⅛	258.01617	56.941	23⅛	420.00492	72.649
13¼	137.88678	41.626	18¼	261.58728	57.334	23¼	424.55779	73.042
13⅜	140.50069	42.019	18⅜	265.18294	57.726	23⅜	429.13519	73.434
13½	143.13915	42.411	18½	268.80315	58.119	23½	433.73715	73.827
13⅝	145.80214	42.804	18⅝	272.44789	58.512	23⅝	438.36365	74.220
13¾	148.48968	43.197	18¾	276.11718	58.905	23¾	443.01469	74.613
13⅞	151.20177	43.589	18⅞	279.81102	59.297	23⅞	447.69027	75.005

AREAS AND CIRCUMFERENCES OF CIRCLES (*Continued*)

Diam.	Area	Circum.	Diam.	Area	Circum.	Diam.	Area	Circum.
24	452.3904	75.398	32	804.2496	100.531	42	1385.4456	131.947
24⅛	457.11507	75.791	32¼	816.8650	101.316	42¼	1401.9881	132.732
24¼	461.86428	76.183	32½	829.5787	102.102	42½	1418.6287	133.518
24⅜	466.63804	76.576	32¾	842.3905	102.887	42¾	1435.3676	134.303
24½	471.43635	76.969	33	855.3006	103.673	43	1452.2046	135.088
24⅝	476.25919	77.361	33¼	868.3087	104.458	43¼	1469.1398	135.874
24¾	481.10658	77.754	33½	881.4151	105.243	43½	1486.1731	136.659
24⅞	485.97852	78.147	33¾	894.6196	106.029	43¾	1503.3047	137.445
25	490.8750	78.540	34	907.9224	106.814	44	1520.5344	138.230
25⅛	495.79602	78.932	34¼	921.3232	107.599	44¼	1537.8623	139.015
25¼	500.74158	79.325	34½	934.8223	108.385	44½	1555.2883	139.801
25⅜	505.71169	79.718	34¾	948.4196	109.170	44¾	1572.8126	140.586
25½	510.70635	80.110	35	962.1150	109.956	45	1590.435	141.373
25⅝	515.72554	80.503	35¼	975.9086	110.741	45¼	1608.1556	142.157
25¾	520.76928	80.896	35½	989.8003	111.527	45½	1625.9743	142.942
25⅞	525.83757	81.288	35¾	1003.7903	112.312	45¾	1643.8913	143.728
26	530.9304	81.681	36	1017.8784	113.097	46	1661.9064	144.513
26¼	541.18968	82.467	36¼	1032.0647	113.883	46¼	1680.0197	145.299
26½	551.54715	83.252	36½	1046.3491	114.668	46½	1698.2311	146.084
26¾	562.00278	84.037	36¾	1060.7318	115.453	46¾	1716.5408	146.869
27	572.5566	84.823	37	1075.2126	116.239	47	1734.9486	147.655
27¼	583.20858	85.608	37¼	1089.7916	117.024	47¼	1753.4546	148.440
27½	593.95875	86.394	37½	1104.4687	117.810	47½	1772.0587	149.226
27¾	604.80708	87.179	37¾	1119.2441	118.595	47¾	1790.7611	150.011
28	615.7536	87.964	38	1134.1176	119.381	48	1809.5616	150.796
28¼	626.79828	88.750	38¼	1149.0893	120.166	48¼	1828.4603	151.582
28½	637.94115	89.535	38½	1164.1591	120.951	48½	1847.4571	152.367
28¾	649.18218	90.321	38¾	1179.3272	121.737	48¾	1866.5522	153.153
29	660.5214	91.106	39	1194.5934	122.522	49	1885.7454	153.938
29¼	671.95878	91.891	39¼	1209.9577	123.308	49¼	1905.0368	154.723
29½	683.49435	92.677	39½	1225.4203	124.093	49½	1924.4263	155.509
29¾	695.12808	93.462	39¾	1240.9811	124.878	49¾	1943.9141	156.294
30	706.8600	94.248	40	1256.64	125.664	50	1963.50	157.080
30¼	718.69008	95.033	40¼	1272.3971	126.449	50¼	1983.1841	157.865
30½	730.61835	95.818	40½	1288.2523	127.235	50½	2002.9663	158.650
30¾	742.64478	96.604	40¾	1304.2058	128.020	50¾	2022.8468	159.436
31	754.7694	97.389	41	1320.2574	128.805	51	2042.8254	160.221
31¼	766.99218	98.175	41¼	1336.4072	129.591	51¼	2062.9022	161.007
31½	779.31315	98.960	41½	1352.6551	130.376	51½	2083.0771	161.792
31¾	791.73228	99.745	41¾	1369.0013	131.161	51¾	2103.3503	162.577

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